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SUBTOTAL ESOPHAGECTOMY WITH HIGH INTRATHORACIC ESOPHAGOGASTRIC ANASTOMOSIS IN THE TREATMENT OF EXTENSIVE CICATRICIAL OBLITERATION OF THE ESOPHAGUS

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THE majority of patients who have suffered extensive chemical burns of the esophagus have usually been dependent upon repeated dilatations by bouginage or ultimately upon gastrostomy feeding to overcome the obstruction which inevitably follows healing by cicatrization. The inconvenience and suffering which attend the application of these methods make these unfortunate patients eager for any more satisfactory substitute. One method of solving the problem in the intractable case has been the construction of an external subcutaneous artificial esophagus by one of the various plastic procedures. The recent wave of interest in this type of operation is partly the result of the work of Yudin, who reported 80 cases of cicatricial stricture of the esophagus treated by what he refers to as the "Roux-Herzen" type of esophagoplasty, performed usually in several stages, involving the temporary utilization of a gastrostomy. In Yudin's hands the results appear to have been satisfactory from the standpoint of low operative mortality and ultimate function.

There can be no doubt, however, that this is a formidable procedure. Furthermore, the patient is left with a distinctly abnormal relation of the parts of the upper gastrointestinal tract. The jejunum is attached, usually by a lateral anastomosis, to the cervical portion of the esophagus, often a rather long distance above the highest level of stricture. The stomach is completely by-passed and becomes therefore nothing more than a secretory appendage of the alimentary canal, emptying by way of the duodenum and proximal end of jejunum into the lower portion of the jejunal segment which has been used for the esophagojejunal anastomosis. Although this arrangement is undoubtedly compatible with the maintenance of a normal state of nutrition, it would seem to be desirable to avoid it if possible.

Experience gained in the resection of carcinoma located in the mid-thoracic region has demonstrated that the stomach can be mobilized to such an extent that a very high intrathoracic esophagogastric anastomosis can be performed (1, 2). By applying this principle to cases in which the growth lay at higher and higher levels in the esophagus, it has finally been established that a safe and functionally satisfactory anastomosis can be performed at the highest level within the thorax, actually behind the jugular notch of the sternum (Fig. 1). The application of this knowledge in the treatment of cicatricial obliteration of the esophagus is the subject of this preliminary report.

TECHNICAL CONSIDERATIONS

1. *Necessity for esophagectomy.* In order to obtain the complete mobilization of the stomach required to bring its fundus to the apex of the thorax where the anastomosis is to be performed, it is necessary to sever the stomach from the esophagus at the level of the cardia. It then becomes necessary to remove the esophagus, unless the theoretical possibility of reimplanting the distal end of the esophagus at a lower level in the stomach is entertained. A further reason for removing the esophagus is that an end-to-side anastomosis between the esophagus and the fundus of the stomach is easier to perform and better functionally than a side-to-side anastomosis between these two organs at that level in the chest.

2. *Preservation of blood supply.* (A) The preservation of an adequate blood supply to the level of anastomosis is easily accomplished in the esophagus provided that the level of division is high enough to reach the esophageal branch of the inferior thyroid artery. Division of the esophagus at a high level is of such importance that one should never be tempted to cut it at a lower point even if considerable length is available. The danger of sloughing of the end is too great.

(B) The maintenance of blood supply on the gastric side is dependent upon the integrity of the anastomotic intercommunicating vessels within the wall of the stomach itself. In order to free the stomach so as to relocate it with the fundus in the apex of the thorax, all the attachments excepting those in the region of the pylorus and the pyloric portion of the antrum must be divided. This involves the division of the left gastric artery, the vasa brevia, and the left gastroepiploic artery as well as the smaller anastomotic communications near the cardia from the inferior phrenic, suprarenal, and pericardiophrenic vessels, and the majority of the vessels in the gastrocolic ligament. In order to preserve the arcade of vessels on the lesser curvature side, the left gastric artery must be divided close to its origin from the celiac axis in order to maintain the communication between its ascending and descending branches. In freeing the stomach from its attachments by the gastrolienal and gastrocolic ligaments to the spleen and colon, care must be exerted to avoid injury to the anastomotic communications of the gastroepiploic vessels.

After the extensive mobilization of the stomach has been completed, the only source of blood supply which remains is that which comes by way of the right gastric and right gastroepiploic arteries. The distribution of blood to the fundus, where the anastomosis is to be, depends upon the integrity of the arcades along the curvatures; but the intramural communicating branches of these vessels are of equal importance. It is necessary, therefore, in handling the stomach during the course of the operation, to exert every effort to avoid trauma to its wall and to the vessels within it. Forceps and clamps should not be applied, and great care must be exerted to avoid tearing a vessel which might produce a hematoma in the gastric wall.

3. *Avoidance of stricture at the site of anastomosis.* A circular opening in the stomach wall is made so as to avoid the angles at each end of a linear incision. Of greater importance is the necessity for obtaining prompt and accurate healing of the layers of the anastomosis, especially the mucosa. All unnecessary trauma to these edges must be avoided. To accomplish this I strongly advise against (a) the use of crushing clamps on either side of the anastomosis, (b) the use of the cautery or a chemical caustic, such as carbolic acid, in cutting across the esophagus or stomach, and (c) the use of continuous sutures which of necessity tend to constrict the edges and produce necrosis of the tissue which they embrace.

4. *Details of dissection.* The amount of dissection required in performing an esophagectomy in a case of cicatricial stenosis is much less than is necessary in cases of carcinoma. In the former, nothing more than the removal of the esophagus from just above the upper limit of the lesion to the cardia is needed. In the latter, provision must be made for division of the esophagus at the greatest possible distance above the upper limits of the growth. In the stricture cases, furthermore, the lymph nodes can be ignored, whereas in the carcinoma group all the nodes which can be reached should be removed, particularly those around the lower thoracic portion of the

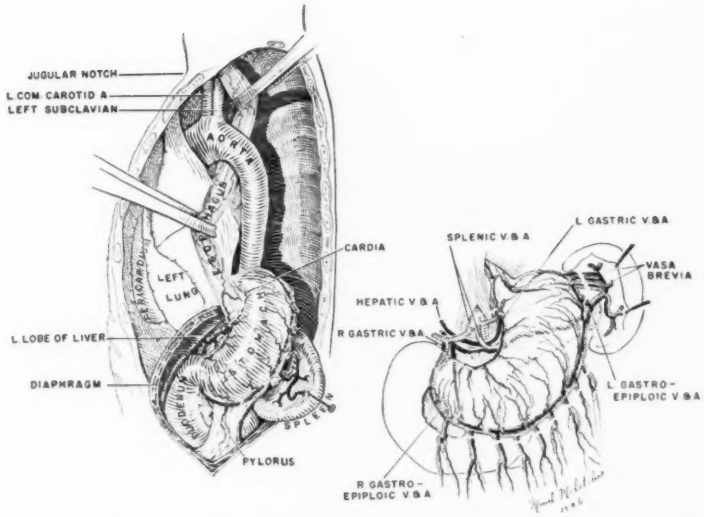

Fig. 1. Diagram to show the amount of dissection necessary in order to remove the entire thoracic portion of the esophagus and to free the stomach sufficiently to perform a high intrathoracic esophagogastric anastomosis at the apex of the chest. View from the left side (Case 3). Inset shows the principal blood vessels of the stomach which must be divided during the process of freeing the stomach: these are the majority of the omental branches of the gastroepiploics, the left gastroepiploic, the vasa brevia, and the left gastric vessels. After division of the cardia, where a few descending branches of the lower esophageal vessels are to be severed, the only blood supply which remains comes by way of the right gastric and right gastroepiploic arteries.

esophagus and the two important groups of nodes which are found below the diaphragm (1).

In spite of these facts, the actual mobilization of the esophagus in a case of cicatricial stricture resulting from a chemical burn is always more difficult than it is in the average case of carcinoma. In the latter, the only difficulty which is encountered occurs at the site of the growth. In the stricture cases, however, the damaged segment is always densely adherent, making it difficult or impossible to find good planes of cleavage for the purpose of dissection. This appears to be the result of an extensive periesophagitis resulting from the burn. It is difficult also, probably as a result of the characteristics of the injury, to discover the exact upper limit of the scarred portion in the esophagus itself, so that after cutting into abnormal tissues at first it is sometimes necessary to choose a higher level for the site of division.

DESCRIPTION OF THE OPERATION

The operative procedure which has been used in the treatment of these cases is essentially the same as that which has been applied in the management of cases of carcinoma of the midportion of the thoracic esophagus (1, 2, 3). A brief outline follows:

1. Intratracheal ether oxygen anesthesia is used.

2. The patient is placed on his right side; the left arm is held forward with the hand in front of the face.

3. Intravenous infusion of saline and transfusions of whole blood are given through a hand or forearm vein.

4. The incision is made over the eighth rib on the left side with its posterior portion curved upward between the scapula and the spine. The eighth rib is resected. If the stricture begins at a high level (as in Case 3), it is necessary to divide one or more ribs posteriorly, the number depending partly on the upper

level of the lesion and partly on the configuration of the patient's chest, whether long or short, and the slope of the ribs.

5. The wound edges are protected with pads of gauze and a rib spreader is inserted. The lung is retracted.

6. The esophagus is then dissected free below the aortic arch. If the stricture extends above the arch, the upper thoracic portion of the esophagus is then freed through an incision in the mediastinal pleura posterior to the thoracic portion of the left common carotid artery. By working both from above and below, the portion behind the aortic arch can be freed from its attachments and the entire thoracic portion of the esophagus is then available for resection. During the performance of this dissection, the small branches from the aortic arch and the bronchial arteries and the usual esophageal branches from the descending portion of the aorta must be severed and tied. The thoracic duct may be encountered as it crosses the esophagus just above the aortic arch. If it is injured, it must be tied so as to avoid the development of a chylous hydrothorax. (This had to be done in Case 3.)

7. The next step is the mobilization of the stomach (Fig. 1). To accomplish this, the diaphragm must be incised from close to its costal insertion laterally through the hiatus. The phrenic nerve is crushed to maintain immobility of the diaphragm. The upper two-thirds or more of the stomach are freed by dividing the gastrocolic ligament with its numerous vessels (branches of the gastroepiploics), the gastrolienal ligament containing the left gastroepiploic vessels and the vasa brevia, and the gastrohepatic ligament with the left gastric vessels. The left gastric artery is cut close to its origin from the celiac axis so as to preserve the integrity of the anastomosis between its ascending and descending branches. The retroperitoneal attachments of the stomach to the diaphragm near the cardia are divided. Here one encounters several small vessels which must be tied (branches of the phrenic, pericardiophrenic, and the suprarenal arteries).

If the patient has a pre-existing gastrostomy, it can be taken down from within the abdomen and the opening in the anterior gastric wall closed with two layers of sutures (Case 3).

The stomach is cut across between clamps just distal to the cardia. The proximal end is covered by tying a rubber glove or piece of rubber dam over it. The distal portion is inverted by means of two layers of fine catgut reinforced with interrupted silk sutures.

8. The esophagus can now be drawn up from behind the aortic arch and turned outward in a position convenient for the performance of the anastomosis (Fig. 2). At a high level on the fundus of the stomach a circular incision of appropriate size is made through the serosal and muscular coats. The small vessels encountered are ligated with fine silk so as to diminish as much as possible the amount of bleeding during the completion of the anastomosis. This portion of the fundus of the stomach is then placed in the apex of the chest and a three layer anastomosis is performed between the end of the esophagus, where it is cut across above the level of the stricture, and the circular opening in the stomach wall which results from excising the portion previously outlined by incision through the serosa and muscularis. Interrupted sutures of fine silk are used. The sutures of the mucosal layer are placed in such a way that the knots lie within the lumen when tied.

9. The anastomosis having been completed, the stomach should be fastened within the chest by means of a series of fine silk sutures (Fig. 3).

10. The edges of the diaphragm are fastened to the antral portion of the stomach where it passes through and the remainder of the opening in the diaphragm is closed with interrupted silk sutures.

11. A catheter for closed suction drainage is brought out through a small incision in a lower interspace posteriorly.

12. Closure of the chest is effected by careful anatomical approximation of the several layers using interrupted silk sutures. The lung should be fully expanded first.

POSTOPERATIVE MANAGEMENT

The handling of these cases after operation differs in no respect from that used in the

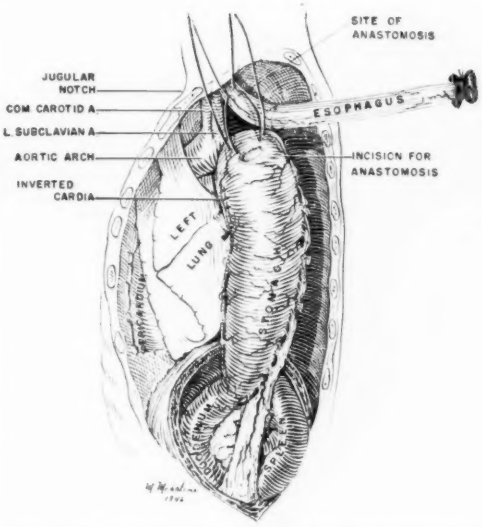

Fig. 2. Diagram to show the start of the anastomosis (as in Case 3). The esophagus has been dissected completely from the mediastinum and pulled up from behind the aortic arch. A circular incision is shown high on the anterior aspect of the fundus; a circular piece of gastric wall is to be removed at that point for the end-to-side esophagogastric anastomosis. The site of transection of the esophagus for the anastomosis is indicated. Note that the duodenum has been drawn to the left and upward by the displacement of the stomach into the chest; the pylorus then comes to lie just below the diaphragm.

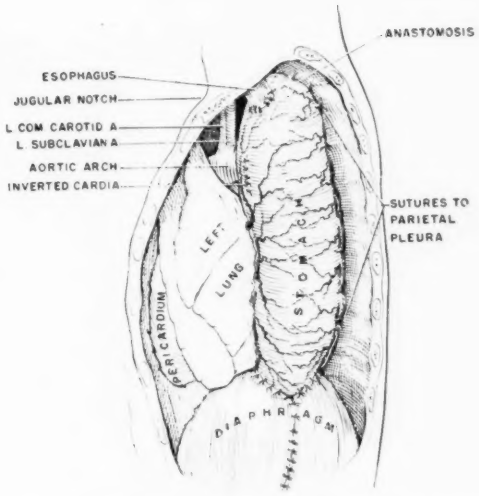

Fig. 3. Diagram to show the anatomical relations of the viscera after the completion of the anastomosis (as in Case 3). The anastomosis lies opposite the jugular notch. The stomach is in front of and somewhat lateral to the aortic arch. It lies behind the hilum of the left lung and against the vertebral column and descending aorta. The diaphragm has been sutured around the stomach just proximal to the pylorus. The remainder of the diaphragmatic incision has been closed. The stomach has been fixed in the chest by means of interrupted sutures of fine silk to the parietal pleura.

carcinoma group. Patients who have strictures from chemical burns are more likely, however, to be much younger than those who suffer from carcinoma and their recovery is therefore somewhat more prompt and less complicated.

REPORTS OF CASES

Three patients who had suffered cicatricial obliteration of a large portion of the esophagus as a result of chemical burns were treated by radical esophagectomy. In 2 of these the upper limit of the lesion was low enough to make it possible to perform the anastomosis a short distance below the arch of the aorta. In the third, the proximal extent of the obstructed area was so high that the anastomosis when completed lay behind the level of the jugular notch. In this case a subtotal esophagectomy was performed. That such a high level of intrathoracic esophagogastric anastomosis is possible will be appreciated by considering the fact that the apex of the thoracic cavity rises several centimeters above the level of the first rib. Thus a high anastomosis, which on first thought might appear to be in the neck, is actually within the thorax at its highest portion.

Case 1. F. J., MGH 323121, male, aged 18 years, was admitted to the Baker Memorial Hospital on December 12, 1943, because of difficulty in swallowing, present since an early age. The exact nature of the injurious substance which this child swallowed was never discovered, but the characteristics of the injury to his esophagus were in every respect consistent with the ingestion of a solution of lye or some other corrosive substance. Dilatation of the esophagus had been performed on three separate occasions with temporary improvement, but each time he had again gradually become unable to swallow anything except liquids. He had lost 18 pounds in the 2 weeks immediately before he was seen.

Physical examination showed a tall, thin, malnourished, underdeveloped boy with a moderate

Fig. 4. Case 1. Roentgenogram of barium filled esophagus before operation. Lowest level of apparently normal esophagus is in the midthorax. There is almost complete obliteration of the lumen in the lower third.

Fig. 5. Case 1. Roentgenogram obtained after ingestion of barium after operation. The upper half of the stomach lies within the chest. The site of anastomosis is shown in the midthoracic region. It should be noted that the prominence observed along the lesser curvature side of the intrathoracic portion of the stomach is the result of the inversion of the cardia. The anastomosis is at the apex of the fundus.

pectus excavatum. Examination was otherwise negative. Blood pressure was 110–60.

Roentgen examination revealed a stricture of the lower third of the esophagus beginning at approximately the level of the inferior pulmonary vein and extending to the cardia.

Photo. hemoglobin was 14.5 grams, white blood count 7700. There were 64 polymorphonuclear leucocytes, 3 large lymphocytes, 20 small lymphocytes, 8 monocytes, 3 eosinophils, and 2 basophils. The red blood cells appeared fairly normal and the platelets were slightly increased. The nonprotein nitrogen was 20 milligrams per cent. The urine was normal.

On December 20, 1943, a resection of the esophagus with esophagogastric anastomosis was performed. A long oblique incision was made across the left side of the chest and the ninth rib was resected. The chest cavity was opened. The lung appeared normal. There were no adhesions. The mediastinal pleura was incised behind the hilum of the lung, and the esophagus was gently freed. The area of stricture was identified opposite the level of the inferior pulmonary vein and extended from that point toward the cardia for a distance of several centimeters. This portion of the esophagus was rigid, thickened when palpated, but not very abnormal in appearance. When this area was dissected up, however, it was found that the outer coats of the esophagus were considerably thickened with scar tissue and the right vagus nerve was caught in scar tissue and could not be freed. The fibers of the left vagus nerve were multiple and it was impossible to preserve more than a few of them.

The esophagus was cut across below the level of the stricture. The point of division actually went through the lower margin of this strictured area and in order to determine how high the lesion went, the proximal end was incised with the scissors. In this way it was found that the upper end of the diseased area, where the esophagus was completely denuded of mucous membrane, had a long tongue-like projection on the right posterior aspect of the lumen which went up to a point above the level of the inferior pulmonary vein. The esophagus was then cut across obliquely, the highest point of the incision across it being just above the point where this upward extension was and the lowest point being on the opposite side, namely the lateral aspect. The distal end of the esophagus was tied with heavy silk and inverted by means of a pursestring suture of silk reinforced with a row of mattress sutures.

The diaphragm was then opened through the hiatus. The attachments of the stomach to the diaphragm were freed. The vasa brevia were divided and in this way it was not necessary to remove the spleen. The stomach was long and it was therefore relatively easy to bring the fundus of the

stomach high in the chest. It was necessary, however, to divide the branch of the left gastric artery which extends toward the cardia. When this was done the fundus could be pulled up to the level of the aortic arch. A high esophagogastric anastomosis was then carried out, three layers of sutures being used. When completed the anastomosis lay above the inferior pulmonary vein at the level of the left main bronchus. The stomach was suspended in its new position by means of a row of sutures between it and the pleura along the side of the vertebral column.

The cut edge of the pulmonary ligament was sutured to the stomach. The diaphragm was then sutured around it so as to prevent herniation of other viscera and the remaining divided portion of the diaphragm was sutured to itself. The point at which the diaphragm was brought around the stomach was in the region of the antrum, not more than 4 inches proximal to the pylorus which had been pulled upward.

On pathological examination of the specimen a diagnosis of nonspecific ulceration and stricture formation was made.

The postoperative course was completely uneventful. Sulfadiazine, started on the day prior to operation, was omitted on the fifth postoperative day and he was discharged from the hospital in excellent condition on January 7, 17 days following operation. Roentgen examination showed a well functioning anastomosis just below the aortic arch.

The patient has reported for follow-up examinations at intervals since operation. He has no discomfort on swallowing. He has gained weight. He is active and leads a perfectly normal life. He experiences no dyspnea and no subjective symptoms which might be associated with the presence of his stomach in the chest except that sometimes after a large meal he has an awareness of his heartbeat.

Case 2. R. C., MGH 453847, male, aged 5 years, was admitted to the Massachusetts General Hospital on August 28, 1944. In March of 1944 he had eaten some ice cream which had fallen into paint cleaner containing lye. He received burns about the mouth and tongue and was quite ill and unable to take food by mouth for a while. Subsequent to this he had been unable to eat anything except semisolid food. Roentgen examination in June had revealed a stricture of the esophagus and bouginage was carried out at weekly intervals during July and August. He was apparently well otherwise. He had a good appetite and ate well, but regurgitated almost everything he ate.

Physical examination showed a small, slender, male child in no distress. Nothing abnormal was found. Blood pressure 90/65.

Roentgen examination showed a stricture of the lower esophagus 10 centimeters in length. The upper margins were funnel-shaped. No definite ulceration was seen. The stomach was markedly dilated and there was delayed emptying, the cause of which was not determined.

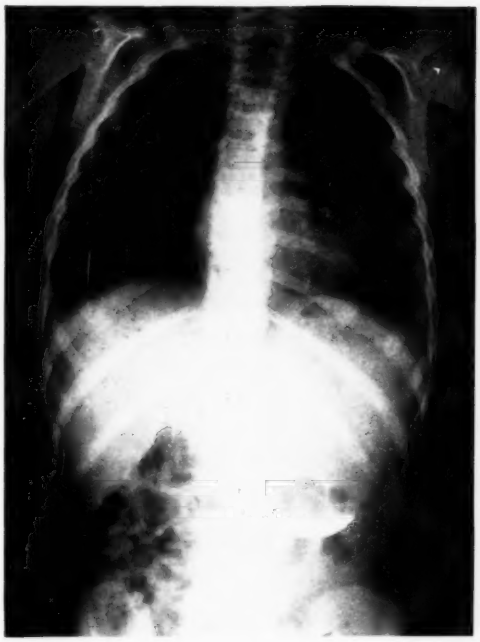

Fig. 6. Case 2. Preoperative roentgenogram obtained after ingestion of barium, showing the stricture in the lower third of the esophagus. The proximal portion is dilated.

Laboratory investigation revealed a nonprotein nitrogen of 23.0 milligrams per cent, protein 6.4 milligrams per cent, and chloride 104.0 mcg 1. The white blood count was 9600, photo. hemoglobin 15 grams, red and white blood cells normal, platelets normal.

After a period of preoperative preparation including the administration of sulfadiazine and a transfusion, a transthoracic partial esophagectomy with esophagogastric anastomosis was performed on September 9, 1944. The chest was opened by means of an intercostal incision between the eighth and ninth ribs. In order to obtain better exposure the eight, seventh, and sixth ribs were divided posteriorly. The lower esophagus from the cardia upward for about 2½ inches was apparently normal. From this point up to the level of the left main bronchus there was a hard thickened area which was very adherent by chronic inflammatory adhesions to the surrounding mediastinal structures. Above this, for a distance of an inch and a half below the aortic arch, the esophagus appeared normal.

After freeing the esophagus sufficiently to make resection possible, the diaphragm was opened. The phrenic nerve was crushed. The stomach, which was large, was freed by dividing the left gastroepiploic vessels and the vasa brevia. There were some in-

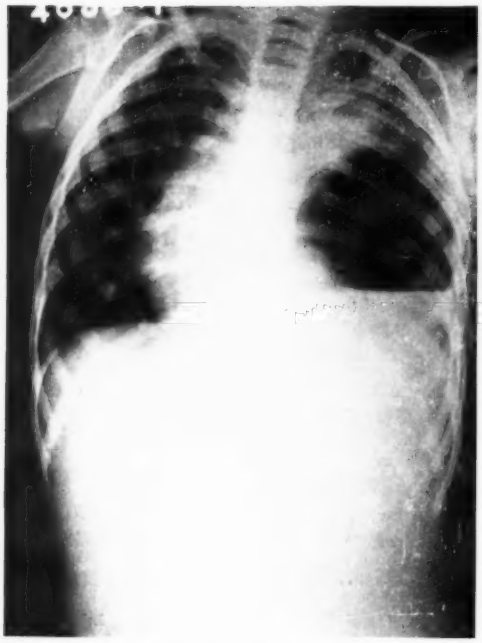

Fig. 7. Case 2. Roentgenogram obtained soon after operation showing the stomach high in the thorax and distended with air. Fluid level is within the stomach.

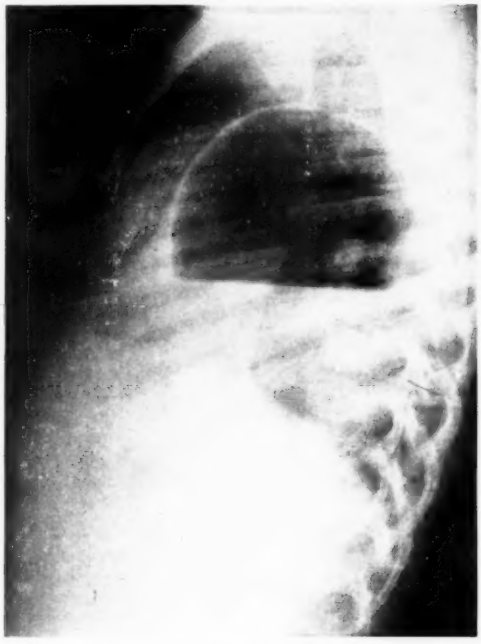

Fig. 8. Case 2. Lateral view same day as Figure 7 showing air-filled stomach in the chest. Fluid level is within the stomach.

flammatory adhesions posteriorly which made the dissection difficult. The ascending branches of the left gastric artery were divided. The esophagus was cut across just above the cardia and the stump was inverted into the stomach. Two layers of silk sutures were used to infold the stump. An anterior circular incision was made on the stomach wall and a three layer, fine silk esophagogastric anastomosis was carried out above the level of the inflammatory stricture, and the diseased area was resected.

The fundus of the stomach was fixed in the chest by means of a number of sutures so as to prevent any pull upon the anastomosis. The pylorus was inspected and found to be apparently normal. The diaphragm was closed around the stomach. The chest wall was then approximated in layers with pericostal sutures of catgut in the first layer and interrupted silk in the remaining layers. No drainage was employed.

On pathological examination a diagnosis of chronic inflammation with ulceration was made.

The patient's recovery from the operation was good. Chemical balance was well maintained. He received 1 ounce of water each hour on the second day following operation. Sulfadiazine had been begun on the day prior to operation and was continued until the fifth postoperative day. Roentgen examination of the chest 3 days after operation showed collapse of the left lung. This expanded gradually but completely. Roentgen examination following a swallow of barium prior to discharge from the hospital showed a normally functioning stoma and marked improvement in the passage of barium through the pylorus into the duodenum. He left the hospital in good condition on September 30, 1944, 21 days after operation.

Since operation he has had no difficulty in swallowing. His weight gain has been slow, but investigation has revealed that his eating habits are poor and that the other members of his family are all of slight build.

Case 3. O. C., MGH 406561, female, aged 27 years, was admitted to the Massachusetts General Hospital on October 11, 1945. She had been unable to swallow anything since January 21, 1942, when during a period of postpartum depression she had attempted to commit suicide by swallowing about a tablespoonful of Drano, which is a solution of lye used for cleansing drain pipes. Frequent dilatations had been attempted but were unsuccessful. After one of these dilatations the patient showed evidence of acute mediastinitis which resulted in the development of acute empyema on the right side. She recovered after rib resection for drainage. In March, 1944, a gastrostomy had been performed by means of

Fig. 9. Case 3. Preoperative roentgenogram after ingestion of barium. The upper level of the stricture is at the jugular notch. The entire thoracic portion of the esophagus is involved in extensive cicatrization and cicatricial obliteration. Note the shadow at a higher level in the neck thought at first to be barium within a diverticulum, but later proved to be the result of obstruction produced by a cicatricial web at that level.

Fig. 10. Case 3. Roentgenogram outlining the stomach after completion of the second operation. The anastomosis lies at the level of the jugular notch.

which she could feed herself, but she was unable even to swallow her saliva and was kept awake at night by continual cough caused by this difficulty.

At the time of first examination, in July, 1944, she had been extremely thin, but in the interval between then and the present admission she had gained some 15 to 20 pounds. Physical examination was negative except for the presence of a scar of empyema drainage, performed in 1942, and an epigastric vertical scar with a 0.5 centimeter gastrostomy opening in excellent condition. Blood pressure was 108/94.

Roentgen examination revealed complete obstruction of the esophagus beginning at the level of the jugular notch where there was a funnel-shaped gradual narrowing. Below this point only a trace of barium could be seen to pass through. There was a shadow at the junction of the hypopharynx with the esophagus which was thought to indicate the presence of a pulsion diverticulum.

Laboratory studies showed a nonprotein nitrogen of 23 milligrams per cent, total protein 7.3 milligrams per cent, and a chloride of 94 milligrams per cent. The white blood count was 7200 and the Tallquist hemoglobin 80 per cent. The urine was negative.

A transthoracic esophagectomy with a high esophagogastric anastomosis was performed on October 16. The left side of the chest was opened and the eighth rib was resected. In order to gain adequate exposure for a subtotal esophagectomy, it was necessary to divide the seventh, sixth, fifth, and fourth ribs posteriorly. The mediastinal pleura was then incised and the esophagus was exposed. It was surrounded everywhere by a dense layer of thick fibrous tissue. This fibrous tissue, which prevented the development of planes of cleavage in which a dissection could be carried out, was thicker in some places than in others. It was particularly dense and difficult to dissect just below and behind the aortic arch. At this level, after a long and painstaking dissection from both above and below the arch, it was finally discovered that the esophagus had narrowed down to an extremely small circumference, having almost no evidence of a lumen at this level. Because it was so difficult to free it from the bronchus and lower end of the trachea at this point, the esophagus was finally cut from below and above the arch, a small portion being left attached. In this case the thoracic duct was inadvertently cut across, but it was recognized and each end was tied.

The diaphragm had been previously opened so as to free up the stomach. The freeing of the stomach was completed by cutting the vasa brevia, the left gastroepiploic and the left gastric vessels, and incising down the gastrocolic and gastrohepatic ligaments. The lower end of the esophagus was cut across. The distal stump was inverted with a silk pursestring suture reinforced with several mattress sutures of silk. The proximal end of the esophagus was pulled out from behind the aortic arch, and the upper limit of the stricture was found to be as shown by the x-ray at or slightly above the level of the jugular notch. This site necessitated pulling the fundus of the stomach up to the base of the neck. At this level a difficult three-layer anastomosis was performed between the cut end of the esophagus and the circular edge of stomach which remained after the excision of a small round piece. The posterior portion of the cut edge of the esophagus had some scar tissue in it; anteriorly the wall was more normal.

After the anastomosis had been completed, the stomach which had been brought all the way up the length of the chest was sutured with a row of fine silk sutures extending from the apex of the chest down to the diaphragm. The diaphragm was then closed around the lower end of the stomach just above the displaced pylorus. Penicillin was inserted both above and below the diaphragm. The wound was then closed in layers by means of silk, after a catheter was brought out through one of the lower interspaces.

On pathological examination a diagnosis of acute and chronic inflammation with ulceration was made.

The patient's recovery from operation was good, but it was realized a week later that she still could not swallow as well as she should. At first she was able to swallow fluids well, but finally even this was difficult. There was obstruction to the passage of a Levine tube at the level of the sternal notch. An attempt was made at this time to have her swallow barium, but she was unable to do so. A roentgenogram obtained after the administration of a swallow of barium had on all previous examinations shown a shadow which was thought to indicate the presence of a pulsion diverticulum of the pharyngoesophageal junction. An attempt to visualize the anastomosis through an esophagoscope was unsuccessful. It was therefore concluded that there must be a stricture at the site of the anastomosis. It was decided to explore this by opening the esophagus through the diverticulum and to correct the difficulty by manipulation through this opening.

On December 11 an oblique incision was made along the course of the anterior border of the sternomastoid muscle on the left side. The usual exposure to remove a diverticulum of the esophagus was then obtained, going in above the omohyoid muscle. There was no diverticulum to be found. A longitudinal incision was therefore made through the wall of the esophagus and on palpation downward an obstruction was met about halfway down the neck. The incision was then enlarged down to the jugular notch and the entire length of the esophagus was exposed. In doing this it was necessary to divide the inferior thyroid vessels, the ansa hypoglossi nerve, the omohyoid muscle, and the lower attachments of the pretracheal muscles. The exposure was excellent.

The esophagus was then incised below the obstructed point, and at this level the lumen was entirely open and the mucosa normal. By palpating downward through the opening the index finger could be easily passed through the esophagogastric anastomosis which was not obstructed. The two incisions were then connected and the web-like stricture which had almost completely obstructed the lumen was incised and the resulting mucosal edges were sutured so as to restore the lumen to a normal diameter. Silk was used. The longitudinal incision was then sutured with three layers of silk, one in the mucosa, one drawing the edges of the muscularis together, and a third folding it in. Before this was done a soft Bardex catheter was inserted with the funnel-shaped end downward through the anastomosis, the tip end upward into the mouth, to be brought out through the nose after completion of the operation. Penicillin was then inserted in the deep spaces of the neck and behind the esophagus, and the wound was closed in layers with silk technique without drainage.

The patient's convalescence following the second operation was completely uneventful. She was fed a liquid diet through the catheter until the tenth day when the catheter was removed. From that time on she was gradually allowed more and more food until the time of her discharge from the hospital when she was taking a liberal soft solid diet. She was discharged in excellent condition on the eighteenth day after the second operation. Roentgen examination following a swallow of barium showed the anastomosis to be functioning with no difficulty (Fig. 10). There was no delay in the passage of barium and the previously described narrowing of the cervical portion of the esophagus was no longer present.

She has done well since returning home. She has reported by letter recently that she has no difficulty swallowing and that she can eat anything even peanuts.

RESULTS OF OPERATION

All three patients made a complete recovery, complicated in the third case by the necessity for a secondary operation for the relief of a previously unsuspected web-like stricture in the cervical portion of the esophagus. All have resumed a normal existence. The first patient, as a result of the operation, has been able to eat normally for the first time since infancy. The second patient appears to be developing in a normal manner consistent with his age although he does not weigh as much as most children of his age.

The other two have gained in weight. In no case is the patient aware, so far as subjective sensations are concerned, that the stomach lies within the chest. The first patient, a rather high strung individual, occasionally experiences attacks of palpitation, usually as a result of excessive exertion soon after eating. He has been able however, to engage in competitive games and athletic exercises at school. All three patients are apparently perfectly well and free from physical handicaps.

SUMMARY AND CONCLUSIONS

The advantages of esophagectomy followed by the performance of an esophagogastric anastomosis are obvious and important. First, the procedure can usually be carried out in one stage. This not only diminishes the amount of discomfort and annoyance to the patient, but it should also shorten the period of hospitalization. In the second place, there is less interference with the normal relation of the parts of the upper alimentary tract to each other. The food is delivered directly into the stomach instead of into the jejunum. Thus the amount of food which can be taken at one time is more nearly normal. From the subjective standpoint the patient is more comfortable and psychologically has the feeling that he has been restored functionally at least to a normal state. In cases of intractable stricture of the esophagus resulting from chemical burns, therefore, an esophagectomy followed by a high intrathoracic esophagogastric anastomosis is superior anatomically, physiologically, and psychologically to any form of external esophagoplasty as a method of restoring the functional continuity of the upper alimentary canal.

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SUPPURATIVE CHOLANGITIS COMPLICATING SIDETRACKING OPERATIONS OF THE BILIARY TRACT

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As a result of obstructive lesions of the extrahepatic bile ducts, it often becomes necessary to perform various types of sidetracking operations in order to divert the biliary stream. While this usually proves to be a safe and efficient procedure, serious complications due directly to the operation sometimes occur. By far the most hazardous complication is suppuration in the biliary tract.

REVIEW OF THE LITERATURE

In 1882 Winiwarter performed the first sidetracking operation for obstructive jaundice in man, anastomosing the gall bladder and colon in seven stages over a 17 month period. Six years later, Oddi reported on his use of cholecystogastrostomy in dogs, noting that it was safer than cholecystenterostomy, since Harley and Gaston had 6 deaths in 7 cases in which the latter operation was done on dogs. The same year Riedel reported the first choledochoduodenostomy in man, and 2 years later Mayo-Robson (34) the first cholecystenterostomy, but in both cases the patients died. The first successful choledochoduodenostomy and cholecystogastrostomy in man were performed by Sprengel in 1891 and Wickhoff and Angelberger in 1893, respectively.

In general the experimental evidence points to the fact that ascending infection in the bile ducts occurs in almost all cases in which direct cholecystogastrostomy or cholecystenterostomy is performed in dogs. Usually the severity of the infection is greatest when the colon is used and least when the duodenum or stomach is used (3, 12, 20, 22, 23, 47). By destroying all lymphatics communicating between the gall bladder and the liver in dogs, Lehman showed that the infection was due to regurgitation from the gastrointestinal tract and not necessarily to spread via the lymphatics. Gentile alone presented experimental evidence to show that hepatitis or cholangitis does not complicate cholecystogastrostomy in dogs, while Weinberg, Wallin, and Binger noted the absence of this complication in monkeys.

The clinical evidence is not so conclusive. Michaux was one of the first to report a case of cholangitis following cholecystoduodenostomy. The inflammation developed 4 weeks after operation, and the patient died 1 month later. Kausch reported 2 cases in which cholecystojejunostomy was done for carcinoma of the pancreas and in which suppurative cholangitis developed 9 months and 4 months later, respectively. Wangensteen described in detail 1 case in which cholangitis developed 8 months after operation. Roeder reported 6 cases in which he performed sidetracking operations. In 2 of these cases, in which he did cholecystoduodenostomy, the patients did well, but of 4 patients who underwent cholecystogastrostomy, 2 died, one 10 days, and the other 74 days after operation. In both cases chills, fever, and jaundice developed. Mason and Baker reported a death due to abscesses of the liver 2 years after cholecystogastrostomy had been done. Eliason and Johnson noted that ascending infection was a complication of cholecystogastrostomy or cholecystoduodenostomy frequent enough to prevent their indiscriminate use. Brunschwig (5) and Whipple (42) also observed cholangitis after cholecystojejunostomy. Puestow, writing on spontaneous biliary fistula, refuted the belief that the formation of internal fistula relieved symptoms referable to the biliary tree. In the 16 cases on which he gave data, all but 4 patients had chills and fever, and all but 1 had recurrent jaundice. In the 1 case without jaundice the cystic duct

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TABLE I.—COLLECTED LABORATORY DATA*

	Date, 1945						
	March 31	April 9	April 12	April 16	April 20	April 23	April 28
Bile in urine†	2	1				3	
Leucocytes, per cu. mm. of blood	17,300	13,800			12,700		
Hemoglobin, gm. per 100 c.c. of blood	14.4	8.6		12.7	10.9		
Urea, mgm. per 100 c.c. of blood	50	28					54
Sugar, mgm. per 100 c.c. of blood	168	285					
Chlorides, mgm. per 100 c.c. of plasma	442	590	557	530	528		
Bilirubin, mgm. per 100 c.c. of serum	24.1 direct	12.2 direct	9.2 direct	27.7 direct		60 direct	63.2 direct
Protein, mgm. per 100 c.c. of serum	5.4	4.4	4.9	5.2	5.1		
Bile in stools	Neg.			Neg.			
Sedimentation rate (Westergren), mm. per hr.	90				59		

*Operation performed April 6, 1945.
†On the basis of 1 to 4, in which 1 designates the least and 4 the greatest concentration of bile.

was obliterated by inflammatory fibrosis, thus protecting the biliary tract from regurgitation of intestinal contents with resulting cholangitis. Colp recently reported that in 2 of 5 cases in which he performed hepaticoduodenostomy, chills and fever developed. In 1 case he did a Billroth II procedure to divert the gastric stream but symptoms continued.

In contrast to the foregoing unfavorable résumé, Mayo-Robson (35) expressed the belief that cholecystenterostomy is a safe procedure, basing his conclusions on 64 cases. White expressed a similar opinion for cholecystogastrostomy after his 3 patients did well. Babcock reported an additional 130 such operations, without evidence of postoperative ascending cholangitis. Moynihan cited 39 of his own cases and did not mention the complication. Steel went so far as to state that the gall bladder resists infection from the bowel. He expressed a preference for cholelithotomy followed by cholecystogastrostomy rather than cholecystectomy in cases of cholelithiasis. Judd and Parker, in discussing palliative procedures for carcinoma of the pancreas, stated, "It is expected that infection will result from direct extension or by the periductile lymphatics; this would not be likely to occur within the life expectancy period." Yet, in the same report, they stated that 2 of 62 patients who underwent operations for stenosis of the bile ducts and 1 of 9 patients on whom operation was performed for carcinoma of the bile ducts had chills, fever, and jaundice in the postoperative period. Oppenheimer and his co-workers had no cases of cholangitis in their 34 cases of cholecystogastrostomy. Bardeleben, Kehr, and Bernhard also expressed the opinion that cholangitis is no serious objection to cholecystenterostomy, and Lehner stated his belief that cholangitis, even when it does develop, is not a serious complication, since it is only temporary.

Recently, a patient who had suppurative cholangitis shortly after direct cholecystogastrostomy had been performed for obstructive jaundice, came under our care.

REPORT OF CASE

A white man, 64 years of age, was admitted to the Mayo Clinic on March 31, 1945, with a history of abdominal pain for 1 year and jaundice for 6 months. The past history revealed only persistent glycosuria for 8 years. The present symptoms had started in July, 1944, with vague distress in the upper part of the abdomen, not related to meals and rather persistent. There were associated mild anorexia and some loss of weight. The patient stated that at that time he had been put on a special diet and given 40 units of protamine-zinc insulin and 20 units of regular insulin parenterally daily, since his physician had felt that his diabetes was responsible for the symptoms. In September, 1944, icterus, light stools, dark urine and intermittent vomiting developed. The jaundice cleared somewhat over the following weeks. As the result of roentgenologic studies a nonfunctioning gall bladder and a normal stomach had been reported. However, the symptoms continued, becoming worse 2 weeks before the patient came to the clinic. In addition, intermittent diarrhea developed.

Physical examination on admission to the clinic revealed severe icterus, an enlarged, tender liver, and

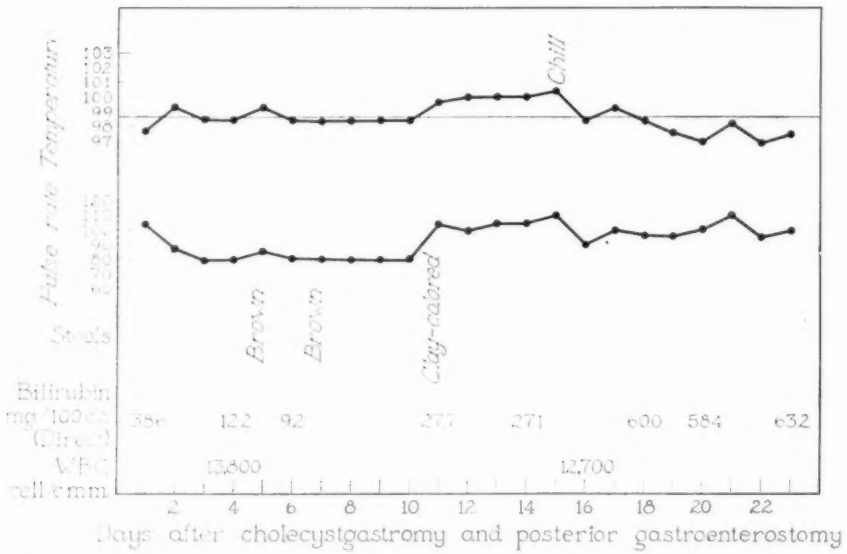

Fig. 1. Very mild constitutional reaction to suppurative cholangitis following cholecystogastrostomy. Patient died on twenty-third postoperative day. Essential laboratory work is also included.

a palpable gall bladder. The temperature, pulse, and respirations were normal. The essential laboratory findings are included in Table I. On the basis of roentgenologic examination considerable dilatation of the stomach and first portion of the duodenum and a duodenal deformity in the region of the ampulla of Vater suggesting a neoplasm, not primary in the duodenum, were reported.

Operation was performed on April 6, 1945. A mass involving the head of the pancreas and the medial wall of the duodenum was found. This was producing obstruction of both the duodenum and the biliary tract. The liver was enlarged, very firm, and deep green. The gall bladder and the common duct were dilated considerably. There was some ascites. Posterior gastroenterostomy and direct cholecystogastrostomy were performed. The bile was clear and green. Five grams of sulfanilamide were left in the upper part of the abdomen.

The postoperative course is shown in Figure 1. The temperature was normal until the eleventh day, when it rose to 99.6 degrees—100 degrees F. and remained at this level for 5 days. The patient experienced a chill on the fifteenth day and the temperature rose to 100.4 degrees F. However, it promptly returned to normal. It rose again to 99.4 degrees F. on the seventeenth day for a single reading but soon returned to normal and remained normal or subnormal until death which occurred on the twenty-third day.

On the fifth day edema of the legs and feet, attributed to hypoproteinemia, developed. Consequently, the patient was placed on a high protein diet supplemented by oral administration of 54 grams of amigen (an enzymatic hydrolysate of casein), daily. There was some clearing of the edema. On the eighth day there was drainage of bile-stained ascitic fluid from the incision, and the patient complained of pain in the right shoulder attributed by us to diaphragmatic irritation, possibly from a leak at the anastomosis, which did not heal well as a result of the hypoproteinemia.

The jaundice at first seemed to be clearing and the stools regained color. On the eleventh day, when the temperature rose, the stools again became acholic and the icterus deepened. The serum bilirubin level rose to 60 milligrams per 100 cubic centimeters direct, remaining at this level until death. It was felt that the increasing jaundice was due to a stricture at the site of cholecystogastrostomy, following a leak on the eighth day.

At necropsy the interesting findings were limited to the upper part of the abdomen. The liver was enlarged and brownish green and its surface was studded with small abscesses. These were most numerous on the diaphragmatic and posterior surfaces. The intrahepatic and extrahepatic bile ducts were greatly dilated and were filled with thick yellow pus and granular material. The pancreas had a carcinoma in the head obstructing the pancreatic and common bile ducts. There was evidence of infection around the head of the pancreas. The anastomoses were patent and the suture lines intact. Microscopic examination of the organs confirmed the gross anatomic impressions and also revealed a few small metastatic regions in the liver.

TABLE II.—FREQUENCY OF CHILLS AND FEVER IN 209 CASES OF SIDETRACKING OPERATIONS FOR MALIGNANT OBSTRUCTION OF THE BILIARY TRACT (1937–1943)

Operation	Chills and fever before operation	Chills and fever before and after operation*	Chills and fever after operation
Cholecystogastrostomy	10	0	12
Cholecystoduodenostomy	1	1	0
Cholecystojejunostomy	0	0	1
Choledochogastrostomy	0	0	0
Choledochoduodenostomy	4	1	1
Choledochojejunostomy	1	0	0
Totals	16	2	14

*These cases are included among the cases in the preceding column.

TABLE III.—RESULTS OF 209 SIDETRACKING OPERATIONS FOR MALIGNANT OBSTRUCTION OF THE BILIARY TRACT (1937–1943)

Operation	Chills and fever before operation		No chills or fever before operation, cases	Chills and fever after operation only, per cent*
	Total cases	Cured by operation, per cent		
Cholecystogastrostomy	10	100	139	9
Cholecystoduodenostomy	1	0	11	0
Cholecystojejunostomy			12	8
Choledochogastrostomy			1	0
Choledochoduodenostomy	4	75	29	3
Choledochojejunostomy	1	100	1	0
All operations	16	88	103	7

*Percentage of cases in each group in which there were no chills and fever before operation.

The true nature of things was not fully appreciated before the death of the patient. It was felt that there was either a stenosis of the anastomosis between the gall bladder and the stomach or a metastasis in the hilus of the liver producing further obstruction of the biliary tract. The relatively normal postoperative temperature, the only slightly elevated neutrophil leucocyte count and the absence of more than only a single mild chill all argued against suppuration. That the infection developed following the operation is supported by the finding of clear bile in a dilated, although otherwise normal biliary tract at the time of operation, whereas at necropsy not only was the tract dilated but the walls were thickened and the lumen was filled with thick creamy pus. It is well to recall that the anastomoses were patent. *While in most cases of stricture of anastomoses of this type cholangitis does develop, the formation of stricture is not necessary for the development of cholangitis.* In a significant percentage of cases in which necropsy was done following death at variable times after sidetracking operations, cholangitis of greater or less degree was present without an obstruction.

While it may appear that the absence of chills, fever, and increasing jaundice in the postoperative period would argue against inflammation in the biliary tree, this is not necessarily true. Walters and Snell stated that "the gravity of the symptoms is not always an index of the degree of suppuration, and in many cases extensive purulent infection of the biliary passages may develop with only minor systemic manifestations. This is especially true of the cholangitis which may develop in association with stone or stricture. It has been observed many times that actual suppuration in the bile passages may occur without fever."

This fact may well explain the discrepancy between the experimental evidence of almost constant suppuration and the clinical reports by many physicians of the absence of any infection. In experimental work all the animals are subjected to careful postmortem study and no cases of cholangitis are overlooked, whereas only a very small number of human beings are ever so studied. Only at the operating table or at necropsy can a definite diagnosis be established. It is very likely that in many cases that follow a course similar to the one presented here, or in which at first the patient appears to do well after sidetracking operations for malignant obstruction of the biliary tract and then progressive jaundice attributed to hepatic metastasis develops, there is in reality suppurative cholangitis, never recognized because necropsy is not performed after death. In view of this, all figures for the incidence of cholangitis must be looked on as lower limits of the actual incidence.

INCIDENCE OF CHOLANGITIS

Following the case reported here, it was decided to attempt to determine, as accurately

TABLE IV.—FREQUENCY OF CHILLS AND FEVER IN EIGHTY-TWO CASES OF SIDETRACKING OPERATIONS FOR BENIGN OBSTRUCTION OF THE BILIARY TRACT (1937–1938)

Operation	Chills and fever before operation	Chills and fever before and after operation*	Chills and fever after operation only
Choledochoduodenostomy	16	4	10
Cholecystogastrostomy	3	2	0
Cholecystoduodenostomy	1	0	0
Choledochogastrostomy	2	0	0
Cholecystojejunostomy	0	0	0
Hepaticoduodenostomy	1	1	6
Hepaticogastrostomy	1	0	1
Hepaticojejunostomy	1	1	1
Totals	25	8	18

*These cases are included among the cases in the preceding column.

TABLE V.—RESULTS OF EIGHTY-TWO SIDETRACKING OPERATIONS FOR BENIGN OBSTRUCTION OF THE BILIARY TRACT (1937–1938)

Operation	Chills and fever before operation		No chills or fever before operation, cases	Chills and fever after operation only, per cent*
	Total cases	Cured by operation, per cent		
Choledochoduodenostomy	16	75	32	31
Cholecystogastrostomy	3	33	9	0
Cholecystoduodenostomy	1	100	2	0
Choledochogastrostomy	2	100	1	0
Cholecystojejunostomy			2	0
Hepaticoduodenostomy	1	0	8	75
Hepaticogastrostomy	1	100	1	100
Hepaticojejunostomy	1	0	2	50
All operations	25	68	57	32

*Percentage of cases in each group in which there were no chills and fever before operation.

as possible, the incidence of cholangitis developing after sidetracking operations for malignant obstruction of the biliary tract. It was also felt that we might determine how often chills and fever associated with malignant obstruction of the common bile duct were relieved by such procedures. The only way, short of operation or postmortem examination, that we know by which cholangitis after sidetracking operations can be suspected is on the basis of the symptoms of chills and fever, with or without associated jaundice, leucocytosis and increased sedimentation rate. The presence of chills and fever associated with jaundice or biliary colic before operation is also presumptive evidence of cholangitis. We, therefore, used chills and fever as specified as the criterion by which we diagnosed cholangitis, when we were certain that the symptoms were not due to any other factors. All such cases in which operation was performed during the years 1937 to 1943, inclusive, were chosen. There were 209 such cases. In addition, a series of cases of benign lesions, during 1937 and 1938, was investigated to compare the results. There were 82 such cases. The findings are summarized in Tables II to V, inclusive.

It is noted from an analysis of these figures that 88 per cent of these patients who had preoperative chills and fever associated with malignant obstruction of the bile ducts were cured of these symptoms, whereas 7 per cent of those who, before operation, had not had symptoms suggesting cholangitis manifested such symptoms at variable times after operation. *In addition, in 14 cases cholangitis developed following, or as a result of the operative procedure, and in only 2 cases in which chills and fever had been present preoperatively did these symptoms continue postoperatively.* A similar observation is made when dealing with the benign strictures of the common duct, 68 per cent of patients (17 of 25) being relieved of their symptoms by operation and 32 per cent (18 of 57) manifesting these as new symptoms after operation. This latter percentage is considerably higher than that in the malignant group. However, the average life expectancy of the malignant group was very short (a matter of months), whereas that of the benign group was much longer. Is it not likely that, had the patients who had malignant lesions lived longer, the figure would have been higher? This may be surmised, since many of the patients in the benign group who manifested chills and fever did not do so until, in some cases, years had elapsed.

It is also observed that just as many patients in the malignant group had symptoms after operation as before; namely, 16. However, only 2 patients fell into both groups. In

other words, 14 patients were cured of their symptoms and 14 others did not have these symptoms until after operation. Unless the figures are broken down in this manner, this fact is not recognized. The usual observation is merely that cholangitis is present just as often before, as after operation. The most significant observation, then, is missed.

It is rather difficult to explain why the same operation should relieve symptoms in some cases and produce them in others. This may be due to the fact that the patient who has cholangitis associated with obstruction has acquired some resistance to infection, and when the obstruction is overcome and internal drainage is established, resolution takes place. On the other hand, the patient who has not had previous cholangitis suddenly has his dilated biliary tract exposed to intestinal bacteria, in the absence of any previous immunization. Rapid suppuration in such a biliary system follows. This explanation of regurgitation as the cause for postoperative cholangitis is more likely than stricture formation alone, since there is no reason why strictures should develop more often in patients without cholangitis before operation than in those who have cholangitis before operation.

The conclusion that we draw from our analysis of the figures is that if there were means of preventing such postoperative complications from developing, the value of sidetracking procedures would be enhanced manyfold. This is even more true for the benign group, in which the patients are often young, the operative mortality rate is not prohibitive, and the patients do live for a reasonable time after operation.

PREVENTION OF POSTOPERATIVE CHOLANGITIS

Attempts to prevent cholangitis from developing after anastomotic operations between the biliary tract and the intestine or the stomach are not new. In 1904, Monprofit suggested the performance of cholecystenterostomy in the form of a Roux procedure, dividing a loop of jejunum, using the distal segment for the anastomosis and then connecting the proximal to the distal loop further down as an end-to-side procedure. Whipple (43) also used this operation, and in one such case in which the patient died 6 months later, no cholangitis was found at necropsy. Eliot expressed the opinion that the use of cholecystogastrostomy rather than cholecystenterostomy would reduce the incidence of cholangitis. However, Mason was the first to report anastomosing the gall bladder to the stomach in such a manner that the former tunneled its way through the wall of the stomach before it reached the gastric lumen. In this way gastric peristalsis would obliterate the lumen of the gall bladder and thus prevent regurgitation of gastric contents. Roeder, DeBakey and Ochsner, Glassman, Zollinger, and McCaughan and Purcell reported favorably on various modifications of the Mason procedure. Although the operations were done on only a few patients, these authors noted the absence of cholangitis in large numbers of dogs on which this operation was performed, while the incidence of cholangitis was high in dogs on which direct cholecystogastrostomy was performed.

In 1941, Hunt and Whipple (43) suggested using the common bile duct rather than the gall bladder, and anastomosing it to the jejunum. In their opinion the common duct would be more resistant to infection since the pressure within it was greater than in the gall bladder. In 1943, Brunschwig, reporting a one stage pancreatoduodenectomy, performed just such a choledochojejunostomy, protecting the biliary passages still more by anastomosing the afferent and efferent jejunal loops in order to divert the intestinal stream. Orr recently emphasized another principle in performing pancreatoduodenectomy: ". . . . location of the anastomosis between the gall tract and pancreas and the jejunum proximal to the gastrojejunostomy to prevent infection of the gall tract and pancreas." Combining several of the methods mentioned previously, Cole and Reynolds stressed the fact that choledochoenterostomy should be done, and placed first in the line of anastomosis. They mentioned 2 cases in which chills and fever stopped when they interrupted, by a Roux procedure, the loop of jejunum which allowed reflux of food through a vitallium tube. They also suggested partly folding in the wall of the loop of jejunum anastomosed to the biliary tree in such a

manner as to make valves to direct the flow of contents away from the anastomosis of the biliary tract to the jejunum.

All of the procedures mentioned are concerned with preventing regurgitation of intestinal contents, the feeling being that cholangitis developing after the sidetracking operations more commonly performed is often due to direct regurgitation, rather than secondary to stricture of the anastomosis. As previously mentioned, necropsy does reveal a rather high incidence of cholangitis after the usual sidetracking operations in the absence of stricture.

As yet, not enough cases have been reported to help us to come to any definite conclusion as to the value of any of the procedures mentioned previously. Surely, the operations as usually done are far from satisfactory.

CONCLUSIONS

1. Severe suppurative cholangitis may be present in the absence of marked constitutional or local symptoms.

2. Any patient who has mild systemic symptoms in the immediate postoperative period after biliary-gastrointestinal anastomosis should be suspected of having suppurative cholangitis, in the absence of other disease to explain these signs and symptoms. This is especially true if there is associated progressively deepening jaundice.

3. Most patients who have cholangitis associated with obstructive jaundice are relieved of their symptoms after sidetracking operation but an appreciable number of patients who previously did not have chills or fever have these symptoms after such operation. These circumstances are very likely often the result of regurgitation of intestinal contents.

4. Surgical procedures designed to prevent and relieve cholangitis following sidetracking operations for obstructive jaundice are described. The authors quoted reporting these operations stress the prevention of regurgitation of gastrointestinal contents and minimize the rôle of stricture formation in the development of postoperative cholangitis.

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THE SURGICAL SIGNIFICANCE OF AORTIC ARCH ANOMALIES

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IN spite of the complex changes which occur in the fetal vascular network, it is a remarkable provision of nature that such constancy is attained for man in the development of the normal aortic arch and its important branches. It is not surprising that this intricate maturation is occasionally disturbed and some sort of a local malformation is evolved. For more than 200 years medical literature has contained reports of aberrations in development of the arch or of the arteries leading from it. Most of the earlier observations were made by anatomists or pathologists, but within the last two decades there have been frequent attempts to correlate the complaints or the clinical findings in patients with the pathological anatomy which is later detected at the autopsy table. More recently the roentgenologist has provided techniques for recognition of many of these malformations in the living subject. It now becomes incumbent upon the surgeon to provide methods of operative relief whenever this might be required and when it appears feasible.

In the following presentation there has been no effort to discuss, or even mention, all of the anatomical variations which have been observed in the aortic arch and its major vessels. Instead, we have selected only the more common abnormalities which seem to have some possibility of surgical correction or which have been already improved by the operative procedures which are listed. Our studies in this field have been stimulated and advanced by the intelligent guidance of confreres, particularly by Dr. Sidney Farber and his aides in the pathological laboratory and by Dr. E. B. D. Neuhauser in the department of roentgenology.

In a consideration of the congenital malformations of the aortic arch, it is well to begin with some sort of a classification. The following has been used as a working basis; we are cognizant of its defects and omissions, but have employed it because it affords a logical grouping from which our discussion can start.

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CLASSIFICATION OF AORTIC ARCH ANOMALIES

1. Right aortic arch
   - A. Situs inversus viscerum
   - B. Right aortic arch without inversion
     1. Anterior type—arch is anterior to the trachea. Descending aorta is right-sided.
     2. Posterior type—arch passes to the left behind the esophagus. Descending aorta courses to the right of normal left side position.
        - a. Right aortic arch in which the left subclavian artery arises last from the arch and crosses behind the esophagus (Fig. 1)
        - b. Right aortic arch in which no vessel arising from the arch crosses the midline posterior to the esophagus. A vessel may pass in front of the trachea (Fig. 2)
        - c. Right aortic arch with a persistent left aortic diverticulum giving origin to the left subclavian artery and ligamentum arteriosum (Fig. 3)
2. Double aortic arch
   - A. One aortic limb obliterated
   - B. Both aortic limbs patent (Fig. 4)
3. Anomalous right subclavian artery. Arises from the left side of a normal aortic arch and crosses the midline, compressing the esophagus (Fig. 5)
4. Patent ductus arteriosus (Fig. 6)
5. Coarctation of the aorta (Fig. 7)

RIGHT AORTIC ARCH

A right aortic arch represents a persistence of the right 4th branchial artery—instead of the left one which normally forms the fully developed arch in man. In this malformation, the aorta arises in a more or less normal way from the left ventricle and then it courses posteriorly over the right main bronchus. From here it extends in front of the trachea (in the rare "anterior type") and then con-

tinues downward behind the lung root as a right-sided aorta. In the more common "posterior type" the arch passes to the left behind the esophagus and the descending aorta continues downward—not on the right side—but in a position somewhat to the right of its normal position.

Great variations can be found in the origins and the courses of the vessels which come from a right aortic arch. We do not care to describe all of these, for fear of introducing too much confusing data. The classification which has been adopted for right aortic arch cases is by no means inclusive; it is intended to present only the more common malformations.

A. Situs inversus vicerum. These cases are possibly improperly classified under the term of "right aortic arch" since they merely represent a side-for-side reversal of the heart and its vessels. In conjunction with this may be a *situs inversus* of the abdominal organs, but it is more common to have the reversal limited to the heart and aorta. This type of anomaly usually presents no symptoms.

B. Right aortic arch without inversion.

1. The anterior type. The ascending aorta rises to the right over the right main bronchus, the second portion lies in front of the trachea, and the descending part passes downward to the right of the midline. Such an anomaly is rare and is encountered primarily in association with transposition of the great vessels.

2. The posterior type. In all of these cases the aorta extends posteriorly to the right of the trachea and esophagus, and then to the left behind the esophagus, continuing downward in a place which is a little to the right of the normal alignment. This posterior type may be subdivided into three general groups, as summarized in the classification. In each of these three divisions there are certain features in the way of esophageal or tracheal compression which probably can be recognized by roentgenologic studies in a living patient.

In group 2a, and as depicted in Figure 1, a major portion of the arch lies behind the esophagus, but in addition, the posterior wall of the esophagus above this is indented obliquely by the left subclavian artery which has an origin low down on the back side of the arch. Furthermore, the left common carotid artery is apt to originate to the right side of the midline and to course over the anterior surface of the trachea.

In group 2b, and as shown in Figure 2, the arch lies transversely behind the esophagus and no other vessel courses in back of the esophagus. The left common carotid artery can cross in front of the trachea and compress it. Frequently, the left common carotid artery and the left subclavian artery arise from a left innominate artery (a minor image of a normal arch and vessels). The pulmonary artery, by virtue of its attachment through the ligamentum arteriosum (or a patent ductus arteriosus) to the posteriorly displaced aortic arch, is pulled backward and pushes on the trachea.

In group 2c, a general arrangement and disposition of vessels can be found as indicated in Figure 3. The important feature here is a so-called "aortic diverticulum"—of variable size—which is an outpocketing of the distal part of the arch and which gives rise to the left subclavian artery and to the ductus arteriosus (or the ligamentum arteriosum).

The various types of right aortic arch may give little or no symptoms and they are frequently of only academic interest. Eisen found 8 right aortic arches in 288 fluoroscopies of the chest for other pathology; in no case were there symptoms referable to the anomalous arch. It is possible, however, for a variety of complaints to come from these regional malformations—as is testified by many reports including those of Renander, Sprague *et al.*, Spencer and Dresser, Garland, Metzger and Ostrum, Faber *et al.*, and also by the patient described below as Case 1. There may be dysphagia, stridor, dyspnea, cyanosis, hoarseness, cough, pain in the upper chest, and vague sensations in the arms. From a study of pathologic specimens and from illustrations such as Figures 1, 2, and 3, it is clear that symptoms may be derived from the arch behind the esophagus, from the great vessels which cross behind the esophagus or in front of the trachea, from a large aortic diverticulum, or from a pulmonary artery which is held posteriorly by its attachment to the arch.

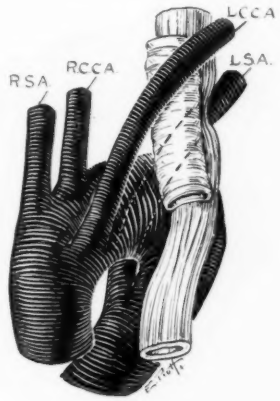

Fig. 1.

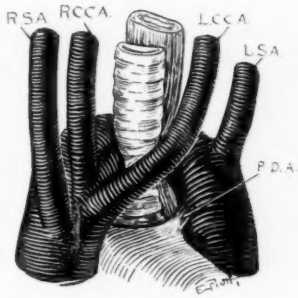

Fig. 2.

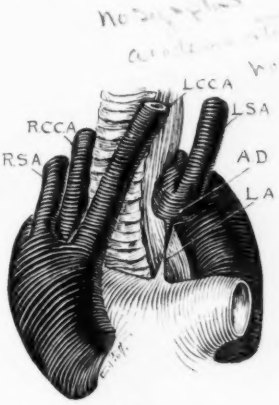

Fig. 3.

Fig. 1. Right aortic arch, with left subclavian artery arising last from the arch and crossing behind the esophagus. *L.C.C.A.*, left common carotid artery; *L.S.A.*, left subclavian artery; *R.C.C.A.*, right common carotid artery; *R.S.A.*, right subclavian artery.

Fig. 2. Right aortic arch, with no vessel from the arch crossing behind the esophagus. Left common carotid artery compressing front of trachea. Pulmonary artery drawn tightly against the trachea by the ductus arteriosus. Case 1, a baby who died from the effects of esophageal and tracheal obstruction. *L.C.C.A.*, left common carotid artery; *L.S.A.*, left subclavian artery; *P.D.A.*, patent ductus arteriosus; *R.C.C.A.*, right common carotid artery; *R.S.A.*, right subclavian artery.

Fig. 3. Right aortic arch with persistent left aortic diverticulum giving rise to the left subclavian artery and the ligamentum arteriosum. Frequently the aortic diverticulum is longer than is indicated here. *A.D.*, aortic diverticulum; *L.A.*, ligamentum arteriosum; *L.C.C.A.*, left common carotid artery; *L.S.A.*, left subclavian artery; *R.C.C.A.*, right common carotid artery; *R.S.A.*, right subclavian artery.

As far as surgical therapy is concerned, none has ever been attempted that we are aware of. It is permissible to surmise that relief could be afforded in some instances when the symptoms are severe enough to warrant such an undertaking. Clearly, many of the local vascular conditions cannot be changed, but at least three possibilities are worthy of consideration. Arteries (such as a subclavian or common carotid) which impinge on the esophagus or on the trachea could be divided or displaced in such a way that this pressure is relieved. An aortic diverticulum, if it is very long, could be removed (and the first part of the left subclavian artery sacrificed); in this way compression of the esophagus could be diminished. A ligamentum arteriosum (or a patent ductus arteriosus) could be divided and thus allow the pulmonary artery to fall forward and away from the trachea.

CASE 1. M. O'D., a 4 month old baby, entered the hospital because of difficulty in breathing and feeding since birth. Mucus frequently collected in the throat and gave rise to severe bouts of coughing, but the infant never became cyanotic. Excessive mucus and coughing were more troublesome when the child was lying on her back. When she was picked up, or her position was changed, these difficulties improved somewhat. Since birth, there had been hesitation in swallowing, and this had become more marked in the month preceding hospitalization. If urged to take more than 1 or 2 ounces she invariably vomited part or all of the previously ingested feeding. Physical examination revealed a poorly developed but fairly well nourished baby. When she was disturbed, the respirations became quite noisy and there was an inspiratory crow. Roentgenographic examination of the chest revealed some peribronchitis. With a swallow of barium in the esophagus, a filling defect could be seen on its posterior wall at the level of the 3rd or 4th thoracic vertebra. The trachea was narrowed just above the carina.

The child regurgitated most of the milk which was offered; gavaging was unsuccessful. Because of the precarious state of health, a gastrostomy was performed for feeding purposes. Evidence of pulmonary infection increased and, on the fifth postoperative day the baby died.

Postmortem examination was confined to the chest. There were present a diffuse, severe bronchopneumonia and early bilateral empyemas. The foramen ovale was still patent. The aortic arch and its respective vessels were found as indicated in Figure 2. There was thus a vascular ring around the esophagus and trachea, formed by the aortic arch behind, the ductus arteriosus on the left, and by the pul-

monary artery in front. In addition, the left common carotid artery apparently compressed the anterior surface of the trachea to some degree. The autopsy findings strongly suggested that the baby might have been relieved by division of the ductus and also by severance of the left common carotid artery (or as an alternative, the carotid artery could have been moved forward and anchored to the back of the sternum).

DOUBLE AORTIC ARCH

Double aortic arch is a rare abnormality in which the ascending aorta splits into two limbs—which encompass the esophagus and trachea, or only the trachea—and then join to form the descending aorta. In normal development, only the left fourth branchial arch persists to form the definitive arterial system according to Congdon. If the right and left branches both remain, a double arch is established. (A bifid aortic arch is the normal arrangement in reptiles.) Such abnormalities in man may be divided into two groups, the first being less common than the second:

A. Partially obliterated double aortic arch. One limb—usually the anterior (left) one—is represented only by a vestigial remnant or cord. The other trunk is patent and functional.

B. Completely patent double aortic arch. Both limbs are open and each carries some blood to the descending aorta (Fig. 4a). The two trunks may be of the same size but they are apt to be unequal. Lockhart studied one specimen in which the right and left arches were equal in caliber—a very rare finding. Blincoe *et al.* collected 12 cases of double aortic arch, in 9 of which the sizes of the respective branches were noted as follows: in 3 cases, the left arch was 15 per cent smaller than the right; in 3 cases, the left arch was 50 per cent smaller than the right; and in 3 cases, the left arch was quite small, but was still patent. The division of the aortic arch into two channels implies that these surround some mediastinal structures. Malacarne, Sagorskij, and Welch described enclosure of the trachea alone, but in all other observations both the esophagus and trachea have been encircled.

It is evident that the confinement of the esophagus and trachea between the two limbs of a split aortic arch has the potentialities for interference with function of these two tubes. Whether or not symptoms develop depends entirely upon the amount of available room which exists between the two vessels. If sufficient space is present there will be little or no compression of the esophagus and trachea—and the individual can live to an advanced age without symptoms, as is exemplified by the patient of Curnow and others. If, however, the space between the aortic limbs is small, the esophagus and trachea can both be constricted so that serious complaints—or even fatality—result therefrom. If complications appear, they are apt to very do so in early life, usually in infancy. Wolman made an excellent study of 7 cases—all infants under 8 months of age—in each of which there was dysphagia and stridor beginning in the neonatal period, and in each there was death from a pulmonary infection. To these patients with symptoms can be added our 2, both of whom were treated surgically. The first of these has been reported elsewhere (13), the second is included herewith as Case 2.

Wolman has very well described the clinical picture which is presented by these infants, and our experiences closely corroborate his observations. Dysphagia and especially stridor occur shortly after birth and persist. These may be mild or they may be severe and continue until death supervenes or surgical relief is instituted. The respirations are noisy and wheezing; they may even have a crowing quality. Suprasternal and intercostal retraction is common. The child is subject to spells of harsh, nonproductive coughing. The cry is hoarse. The respiratory rate is often elevated. During the act of deglutition, stridor is accentuated and cyanosis sometimes appears. Feedings require much time and patience, since swallowing is delayed and the baby must rest at frequent intervals to improve the breathing. The nourishment and general development may be reasonably good, but these patients are quite subject to superimposed respiratory infections. It is this latter factor which accounts for most of the fatalities. Presumably, the tracheal compression—and possibly the spill-over from

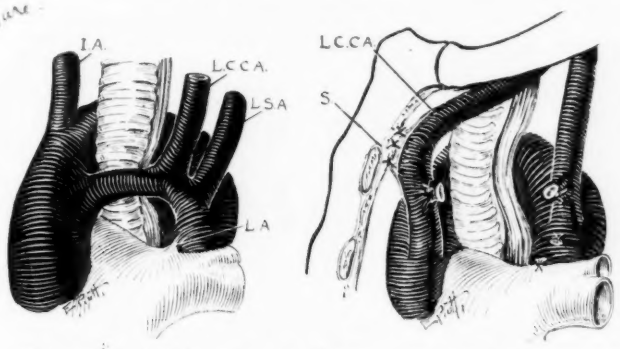

Fig. 4. a, left, Double aortic arch. The ascending aorta divides into two limbs which subsequently join and form the descending aorta. The esophagus and trachea are compressed (Case 2). b, Method of surgical treatment which was employed. The ligamentum arteriosum has been divided to allow the pulmonary artery to fall forward. The anterior (left) limb of the double arch has been severed between the origins of the left common carotid artery and the left subclavian artery. The left common carotid artery is then tacked to the back of the sternum to keep it off the trachea. *I.A.*, innominate artery; *L.A.*, ligamentum arteriosum; *L.C.C.A.*, left common carotid artery; *L.S.A.*, left subclavian artery; *S.*, sternum.

the esophagus—initiate repeated bouts of tracheobronchitis and pneumonia.

Fortunately, the diagnosis of this condition can be readily made during life by roentgenologic means. We are indebted to Dr. E. B. D. Neuhauser for detection of the anomaly in our 2 patients while they were still in a reasonably satisfactory physical condition and could be brought to operative treatment. If the condition is suspected, a swallow of barium and appropriate observations in the lateral and anterior-posterior views will quickly indicate whether there is a compression defect on the posterior esophageal wall. If this is found, films of appropriate density will outline the trachea (because of its air content) and any narrowing can be observed. If the trachea cannot be seen by this simple method, instillation of lipiodol or the use of a lipiodol spray will permit its visualization.

Surgical therapy for this abnormality does not appear to be very difficult. The posterior (right) aortic limb cannot be removed from behind the esophagus, since it is usually the larger of the two channels. However, by dividing some part of the anterior (left) limb, the vascular ring can be broken, the pressure on the trachea can be diminished, and the esophagus can be allowed to displace forward to some degree. In our first case (13) this was the only procedure which was carried out. It provided a marked alleviation of respiratory difficulties, but it did not abolish them. The residual symptoms were thought to be due to the stretching of the left common carotid artery across the upper part of the trachea like a bowstring. To obviate this factor in our second case, the anterior aortic limb was divided (Fig. 4b) and then the left common carotid artery was held forward (off the trachea) by tacking it to the back of the sternum with a few stitches. This additional step has proved to be worth while because the baby has been completely relieved. (In some cases it might be possible to divide the anterior limb between its source and the origin of the left common carotid artery, and in this way the left common carotid artery would be made to lie alongside the trachea instead of stretching across in front of it. Such a division was not done in our two cases because the distal part of this limb seemed to be too small to supply adequately the left subclavian artery and the left common carotid artery. In short, the size of the various parts of the limb must determine where it will be cut.)

CASE 2. C.A.G., a 5 month old baby, entered the hospital in June, 1945, because of stridor, cough,

fever, and respiratory infection of 2 weeks' duration. The child was cyanotic and in marked distress. The breathing was noisy and rapid; there was marked intercostal retraction. She was placed in a steam room and was given oxygen, penicillin, and sulfadiazine. For 2 days her condition was critical enough to require various stimulants, but following this she gradually improved and was discharged on the 19th day.

Following hospitalization, the baby was in fair condition for several weeks and then again developed a cough and noisy respirations, but was afebrile. Because of progressive anorexia and weight loss, hospitalization was again advised in August. Auscultation revealed rhonchi over both lung fields. The breathing was noisy and stertorous. Roentgenographic studies showed indentation of the esophagus from behind (at the level of the 3rd dorsal vertebra) and an anterior compression of the trachea at the same level.

At operation, an anterior exposure through the left pleural cavity permitted dissection of the superior mediastinum so that the arrangement of the vessels could be accurately ascertained (Fig. 4a). Because of the size of various portions of the anterior (left) limb of the double arch, it seemed best to divide it between the origins of the left subclavian artery and the left common carotid artery. This latter vessel then seemed to stretch across the anterior surface of the trachea at a higher level, and to avoid all such pressure the artery was now lifted off of the trachea and held forward by suturing its adventitia with several silk stitches to the periosteum on the back of the sternum. During the first part of the operation the child's respiratory movements were labored, greatly accentuated, irregular, and noisy—a fact which greatly enhanced the anesthetist's difficulties. However, when the indicated operative steps were completed, the respirations were quiet and entirely normal. The left lung was re-expanded and the chest was closed.

Following operation the residual respiratory infection rapidly responded to treatment and the child was discharged on the 12th day. Since that time the baby has been normal in every way. She swallows without hesitation and has had no stridor or other respiratory symptoms at any time. There has been a rapid gain in weight and the parents are delighted with the operative result.

ANOMALOUS RIGHT SUBCLAVIAN ARTERY

One of the commonest anomalies of the aortic arch is that in which the right subclavian artery arises from the left side of the arch and then courses upward and to the right to reach its normal exit from the thoracic cage (Fig. 5a). This artery may run behind the esophagus, between the esophagus and trachea, or in front of the trachea. Holzapfel made an extensive study of this anomaly and found the artery to lie: behind the esophagus in 107 cases, between the esophagus and trachea in 20 cases, in front of the trachea in 6 cases. The vessel usually crosses the midline of the body at the level of the third dorsal vertebra. Holzapfel and others have commented upon the frequency with which an aneurysmal dilatation is found in the first part of the artery—just as it comes off the aortic arch. The appearance of a subclavian abnormality is reported to range from 4 cases per thousand dissections (Quain) to 16 per thousand postmortem examinations (Goldbloom). Holzapfel attributes the first authentic case report to Hunauld in 1735. In 1794 Bayford made a precise and fascinating description of a woman who was known to have marked difficulty in swallowing for many years and who at autopsy was proved to have esophageal compression from this malformation. It was he who gave the name of *dysphagia lusoria* to this condition—meaning thereby that the dysphagia was due to a *lusus naturae* (a trick or deception of nature).

This anomalous vessel may not give rise to any symptoms—indeed it does not do so in the vast majority of cases. It has been frequently described as an incidental finding in dissection room subjects, or in postmortem examinations of elderly individuals who apparently did not have any alteration of esophageal function. More recently, it has been noticed in an incidental way during roentgenologic examinations of the alimentary tract. It is possible, however, for the vessel to press upon the esophagus and to disturb the swallowing mechanism. In Kirby's patient a swallowed bone stuck in the esophagus where the vessel crossed it; a perforation of the subclavian artery led to fatal hemorrhage. The 3 year old patient of Vellock *et al.* died in acute respiratory distress because food had become lodged in the esophagus at this point. In our experience this abnormality has been identified in 6 patients by the roentgenologist. In 4 of these children there seemed to be no important difficulty in swallowing. In the fifth there was sufficient hesitancy in deglutition to bring the child to the hospital but this was spontaneously re-

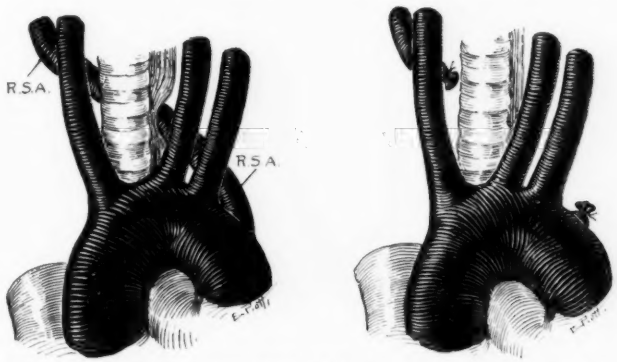

Fig. 5. a, left, Anomalous right subclavian artery, which arises from the left side of the aortic arch and presses on the posterior wall of the esophagus (Case 3). b, Method of surgical treatment for the dysphagia. The subclavian artery has been divided and esophageal pressure thereby relieved. *R.S.A.*, right subclavian artery.

lieved during a few months' observation. In the sixth case there was persistent dysphagia which finally led to surgical exploration for its relief (Case 3 below). This abnormality is not necessarily one which will give its maximum symptoms in early life; there are observations to indicate that the dysphagia may first become manifest, or may be aggravated, in later years when the regional blood vessels become more rigid or become more dilated and thereby press more firmly on the esophagus.

It is now clear that the roentgenologists, by barium visualization of the esophagus, can detect this abnormality with great accuracy. Furthermore, it has been shown that it is possible completely to abolish dysphagia by severing the artery and removing it from behind the esophagus (16). A similar procedure could be carried out when the artery passes between the trachea and esophagus. In short, it is probable that this surgical procedure can be employed for a considerable number of persons who have difficulties—which might not endanger their life—but which are nevertheless quite disagreeable. We do not know of any descriptions of individuals with respiratory distress from a subclavian vessel which passes in front of the trachea. In the event of such an occurrence, division of the artery should be beneficial.

Fortunately, it is possible to divide the first portion of a subclavian artery without serious impairment of blood flow to the arm. This is true because of the collateral vessels which communicate with the second and third portions of the artery and with the axillary artery. Interruption of the subclavian artery in its first portion will lead to a reduced blood pressure and a diminished flow in the extremity, but the remaining circulation is adequate to supply all of the important demands of the limb.

CASE 3[1]. J.R., a 4 month old infant, apparently had marked distress or pain while drinking his milk. This trouble began at about 1 month of age and had increased in severity since that time. The child would be quite hungry, would suck a little, and then would "straighten out with pain." After subsidence of this distress, a resumption of feeding would again bring on fretfulness and crying. There was occasional regurgitation of milk, but no projectile vomiting. At times the baby would take a full feeding, but usually it had to be limited to an ounce or two. It had become necessary to give the baby 15 to 20 small feedings per day to keep up the fluid and caloric requirements. The mother had to spend a major portion of her time in maintaining this schedule. The general physical examination was negative. The radial pulses were equal. Barium examination of the esophagus by Dr. E.B.D. Neuhauser showed a filling defect on the posterior wall of the esophagus which he believed to be characteristic of an anomalous right subclavian artery.

Under cyclopropane anesthesia, the superior mediastinum was explored through a left, transpleural, anterior wound. After a rather easy dissection, an arrangement of vessels was found as

[1] This case has been described elsewhere (16).

indicated in Figure 5a. The right subclavian artery was freed from its retroesophageal bed, the dissection being kept away from the thoracic duct. The vessel was then doubly ligated and divided. Its distal end was allowed to retract to the patient's right—beyond the esophagus (Fig. 5b). The chest was closed after re-expanding the left lung.

Following operation, the color and temperature of the two arms were always equal. Immediately after operation no right radial pulsation could be felt, but there was a faint beat in the right axillary artery. The right radial pulse could be felt on the fifth day. Since that time it has persisted but has been faint. Since operation there has been no hesitancy in swallowing. The child has been placed on a four hourly feeding regimen which is quite satisfactory. The baby was discharged on the tenth postoperative day. Since hospitalization there has been no evidence of dysphagia. Repeat barium examination of the esophagus shows it to be entirely normal.

PATENT DUCTUS ARTERIOSUS

The ductus arteriosus is a shunt between the aorta and pulmonary artery. This by-pass is essential during fetal life, but after birth it normally becomes obliterated and forms the ligamentum arteriosum. If the vessel should remain open the health or longevity of the individual might not be impaired, but such is not the case in most instances. The persistence of this shunt carries certain definite hazards: First, so much blood may be diverted from the peripheral circulation that the physical development is retarded. Second, the large amount of blood which is forced through this arteriovenous type of communication greatly increases the work of the heart and may lead to varying degrees of cardiac embarrassment or failure. Third, the abnormality may become a focus of infection, especially with the Streptococcus viridans organisms. The first hazard is one which will be manifest in childhood, the second and third complications rarely appear before adult life. While some individuals with an open ductus may have a reasonable span of life and little or no complications from it, there is ample evidence to show that in a series of patients the life expectancy is only a little more than half of normal.

In most cases a patent ductus arteriosus can be readily recognized. In infancy the physical findings may be confusing and in later life the presence of cardiac failure may alter the picture somewhat. Except for these circumstances, the diagnosis can be made with great accuracy. There is no cyanosis, clubbing, or polycythemia. The murmur is one which should be rarely confused with the sounds of other cardiovascular defects. It is continuous, has a systolic accentuation, and usually has a rumbling or "machinery" quality. It is loudest in the second or third interspace to the left of the sternum, but it may be transmitted widely in whole or in part. In some instances, it is accompanied by a thrill, which is likewise maximal in the pulmonary area. There are certain features which are absent if the shunt is a small one, but are present if the leak is a large one. These are excessive forcefulness of the heart beat, a lowered diastolic blood pressure, and an increased amplitude of cardiac contraction by roentgenologic observation. The electrocardiograms commonly are normal; they never indicate a right axis preponderance, but occasionally they show some left axis deviation. In general, a patent ductus arteriosus can be recognized (or excluded) by a few minutes of intelligent use of a stethoscope. Laboratory and roentgenologic data may give confirmatory evidence and may be helpful in ruling out other lesions, but too much reliance should not be placed on these accessory aids if the auscultatory findings are not typical of an open ductus.

The indications for surgery are being broadened as more experience is gained with the operative treatment of this condition and as the mortality rate is being lowered to a reasonable figure. For the child or adolescent individual who has retardation of physical growth, closure of the shunt has had a profound effect in augmenting the peripheral blood flow and increasing the subsequent growth and weight of the patient. When there is cardiac embarrassment or failure, stoppage of the ductus leak greatly diminishes the work of the heart and provides a satisfactory cardiac reserve. In the presence of superimposed Streptococcus viridans infection, surgical closure of the ductus in 10 patients[1] was

[1]None of these patients had responded satisfactorily to sulfonamide therapy before operation, but these drugs were continued for variable periods after operation. In no case was penicillin given either before or after operation.

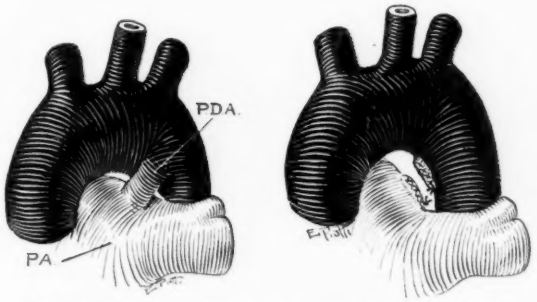

Fig. 6. a, left, Patent ductus arteriosus, forming a shunt between the aorta and pulmonary artery. b, Currently employed method of closure of the shunt. The ductus is completely divided, so that the pulmonary and aortic ends can be individually sutured. *P.A.*, pulmonary artery; *P.D.A.*, patent ductus arteriosus.

followed by no beneficial effects in 3 cases and by complete cure in the other 7. The technical difficulties of operation are considerable if the patient is beyond 20 to 25 years of age and especially so if there is superimposed cardiac failure or infection. For this reason we are convinced that it is advisable to undertake these operations in childhood before the regional vessels have developed a sclerosis which makes the handling of them hazardous. In a series of 130 treated patients, varying in age from 11 months to 47 years, there has been a surgical mortality in 5 instances—a fatality rate of 3.8 per cent. Excluding the adults of the series, there have been 90 operations with but one death—a rate of 1.1 per cent. Since the risks of operation have been kept at this low figure in the childhood group, it appears to be a sound policy to advise closure of the ductus in all young individuals, with the hope of avoiding serious complications in later life.

The method of closure of the ductus merits some discussion. Obviously, ligation of the vessel is the simplest procedure but it has drawbacks which are inherent in ligation of any vessel "in continuity." In a high percentage of cases, particularly in young patients and for the smaller shunts, simple ligation is quite satisfactory; but occasionally it gives a disappointing result. In 43 of our cases ligation was employed. In about 80 per cent of these the result was perfect, in about 10 per cent the ligature partially cut through and some fistula was re-established, in about 10 per cent the ligature was not tied tightly enough to close off all of the shunt. This experience has led to development and adoption of a technique for complete division of the ductus which has now been carried out in 87 instances. The technique which is currently employed is essentially that, with only slight modifications, which has been previously described (15). In these 87 cases there have been 2 surgical fatalities. The first occurred on the operating table; the patient was a 26 year old woman who had been in cardiac failure and who succumbed shortly after the ductus had been divided and its ends closed. The second death occurred 2 weeks after operation from a staphylococcus mediastinitis. Experience with this operation makes it obvious that all of the shunt is completely shut off and that there is no chance for its re-establishment. While the technique may be difficult, the results obtained are so superior that we have completely abandoned the former operation of ligation.

CASE 4. D. E., a 14 year old boy, had some dyspnea on exertion but had never had frank signs of cardiac failure. He had had several prolonged periods when bed rest was advised. A heart murmur was known to be present since infancy. The boy was well developed and nourished. Blood pressure in the right arm was 116 systolic and 60 diastolic. There was a loud, machinery-like murmur, continuous but with systolic accentuation, which was most prominent in the pulmonary area. A promi-

nent systolic thrill was felt in the pulmonary region. Roentgenographic examination showed the transverse diameter of the heart to be slightly more than half of the internal diameter of the chest. The enlargement was particularly in the left ventricle. There was an increased amplitude of pulsation of the left border of the heart. There was an engorgement of the hilar vessels of the lungs. Electrocardiographic tracings were normal.

Operation was undertaken with cyclopropane anesthesia. The ductus was 7 to 8 millimeters in diameter and about 5 millimeters long. Four narrow clamps were applied to it and the vessel was severed between the two middle clamps. The proximal clamp on the pulmonary end was removed to provide a cuff which could be sutured with a running, fine silk stitch. The aortic end was likewise closed. The remaining hemostatic clamps were removed. The chest was closed and the lung was fully expanded.

There were no postoperative complications. The murmur has completely disappeared. The boy was discharged from the hospital on the 11th postoperative day. In the 6 months following operation, he grew 2 inches and gained 15 pounds. He developed an interest in sports and has no limitation of activities.

COARCTATION OF THE AORTA

Coarctation is a narrowing or complete occlusion of the aortic pathway. It has been found in the abdominal and in the lower thoracic portions of the aorta but in the vast majority of instances it is located in the distal segment of the aortic arch or in the uppermost part of the descending aorta, at or near the ductus arteriosus or its obliterated remnant, the ligamentum arteriosum. It has been stated to appear about once in 1500 routine autopsies. Two general forms have been described. In the *infantile* type there is a diffuse narrowing or obliteration of the distal part of the aortic arch so that there is an insufficient supply of blood to the left subclavian artery and possibly to the left common carotid artery. It is usually incompatible with life for more than a short period. In the *adult* type the narrowing is limited to a short segment and appears *beyond* the origin of the left subclavian artery so that it involves that part of the aorta which is joined to the ligamentum arteriosum (or the ductus arteriosus). The separation of cases into these two groups has no sound basis, since the underlying pathological or degenerative processes are probably the same in both. However, the division does emphasize the fact that the "infantile" type is more extensive, is more prone to be associated with severe cardiac malformations, and leads to fatality in the first months of life, whereas the "adult" type is less apt to be associated with marked cardiac derangements and is compatible with a much longer existence.

The adult type of coarctation carries a variable prognosis. A small number of these individuals have attained old age and have had relatively little incapacitation, but the majority of subjects have developed serious or even fatal complications. The aorta may rupture because of the increased strain which is placed upon it and because of the sclerosis which can appear at an early age. An aneurysm, of a localized or a dissecting variety, may originate near the obstruction. The vascular abnormality may become the seat of superimposed infection, particularly with the Streptococcus viridans organisms. Finally, the blood pressure in the upper part of the body usually becomes elevated as a compensatory mechanism. It is not entirely clear whether this hypertension is a direct result of a mechanical blockage in the arterial pathway, or whether it rises from a diminished (or nonpulsating) blood flow to the kidneys. Elevated pressures may be tolerated for long periods of time, but it is obvious that they account for many fatalities on the basis of cardiac failure or central nervous system hemorrhage. Elevations in arterial pressure in the upper part of the body do not bear a direct relationship to the degree of aortic obstruction. The serious nature of coarctation of the aorta is indicated by Blackford's (2) study of 196 cases coming to autopsy; more than 40 per cent of these patients had died between the ages of 16 and 30 years of age.

Any intensive study of the problem leaves little doubt regarding the hazards which must be faced by most individuals who possess a coarctation of the aorta. It is therefore clear that surgical relief is highly desirable for these individuals—provided this can be obtained with a reasonably low mortality rate. Three general surgical approaches can be considered. First, an extensive sympathectomy will diminish the hypertension to

some extent, but how long these beneficial effects will last is still problematical. Second, the aortic obstruction can be by-passed by severing the left subclavian artery at the base of the neck and turning it downward so that it can be anastomosed to the aorta below the obstruction. Blalock and Park have suggested this method, after experimentation on animals, but its efficiency in man is doubtful because severance of the artery would cut off many important channels which invariably come from this vessel. Third, the obstruction may be removed from the aorta and the aortic continuity re-established by anastomosis of its free ends. The feasibility of such a procedure was demonstrated by the experimental work of Gross and Hufnagel (19). It was first performed in humans by Crafoord and it has been further established as a sound surgical procedure by our operative experience in 5 patients.

Coarctation of the aorta can be recognized by quite simple means, the important factor being the detection of an abnormal relationship in the pressures of the arms and legs. Normally, the systolic blood pressure is 20 to 40 millimeters of mercury higher in the legs than in the arms. Pressures of equal magnitudes in the arms and legs are suggestive of a mild aortic block, and lower pressures in the legs certainly indicate an important degree of obstruction in the aorta. Indeed, in most cases of coarctation the pressure in the legs is greatly reduced, and usually cannot be obtained at all with the sphygmomanometer. Palpation over the femoral and other major arteries of the legs shows a marked diminution in pulsation or a complete absence of arterial beats. Hypertension of variable degree may or may not exist in the arms. In children, the pressure in the arms may be relatively normal, but in older patients there is commonly a moderate or marked elevation of pressure in the upper part of the body. If collateral arterial channels have become well developed, and if the individual is not too fat, abnormal pulsations can be seen or felt over these accessory pathways, particularly along the intercostal arteries, over the axillary vessels, and in the regions medial and inferior to the scapulae. Murmurs are extremely variable, and may be quite misleading. Undoubtedly, marked narrowing of the aorta produces a systolic murmur which can be heard over the left upper portion of the precordium and over the back, particularly to the left of the spine. But if the aortic block is complete there may be no murmur at all. Furthermore, the picture is often confused by the presence of associated cardiac defects such as a bicuspid aortic valve, an interventricular septal defect, or a patent ductus arteriosus, which give rise to audible sounds. Furthermore, large and tortuous collateral channels can initiate systolic or even continuous murmurs. It is therefore evident that a murmur *per se*, cannot be relied upon as an important criterion in making the diagnosis of coarctation of the aorta. Roentgenologic findings are such that they are a valuable aid in recognition of the vascular abnormality.

At first glance, direct surgical measures for excision of a constricted portion of the aorta would seem to be fraught with excessive dangers, yet this has not proved to be true in the limited experience which has been accumulated to date. The experimental findings of several observers have shown that in normal dogs the temporary obstruction (by clamping) of the upper thoracic aorta during operation will be followed in many instances by spinal cord degeneration and serious paralysis of the hind limbs. These observations should not be any deterrent to operation in human beings who have a coarctation of the aorta; under these circumstances there is little or no flow of blood through this segment of the aorta, the collateral channels are well developed, and the aorta can be clamped with impunity because this step will not materially diminish the supply of blood to the spinal cord during the period of aortic clamping. Hemorrhage from the aortic suture line might appear to be an insuperable problem, but this was not so in either of Crafoord's 2 cases, nor in any of our 5 patients. It is well to emphasize that the performance of an extremely accurate and careful anastomosis of the aortic ends completely eliminates the possibility of bleeding at the junction. Thrombosis at the site of anastomosis deserves some consideration, but in no instance has there been any evidence of

Fig. 7. a, left, Coarctation of the aorta, with a high degree of constriction and obstruction, just beyond the origin of the left subclavian artery. b, Method of treatment, by excision of the narrowed segment and end-to-end suture of the aorta. Insert shows excised portion—possessing a very tiny lumen.

postoperative blockage of the aorta. Presumably, the establishment of an intima-to-intima anastomosis, combined with the rapid flow through the upper aorta serves to prevent any clotting in this region. It has not been necessary to give these patients anticoagulants during the postoperative period.

One pitfall which has appeared in these operations has been the marked readjustments which must be made in the circulation when the aortic anastomosis has been completed and the clamps are removed from the vessel. By this step, an enormous vascular bed is opened up in the lower part of the body, and the heart may not be able to cope with this strain if it is imposed upon it too quickly. In our first case, it led to an immediate fatality, but in all subsequent cases the clamp was taken off *slowly* (over a 5 to 10 minute period) and the adjustments were thus made in the cardiovascular apparatus in a very satisfactory manner.

The details of operative technique will not be discussed here. They have been presented fully elsewhere (17, 18, 19).

Postoperative studies on our 4 successful cases, and on the 2 which were reported by Crafoord and Nylin, show that there is a very satisfactory appearance of arterial pulsations in the legs and a concomitant fall of the pressure in the arms. The diminution of pressure in the upper part of the body does not take place abruptly—it occurs gradually during the ensuing 10 days to 2 weeks. Presumably, the peripheral vascular bed (in the lower part of the body) is small before operation and a period of time is necessary to dilate it and thereby provide a large enough system to receive blood and relieve the congestion in the upper part of the body.

Case 5. J.S., a 10 year old girl, complained of epistaxis of 2½ years' duration. The bleeding was sometimes copious. There were occasional headaches. Slight dyspnea appeared after light exercise. The child was well developed. The heart was slightly enlarged. There was a grade 2 systolic murmur to the left of the sternum, this could be heard with less intensity over the back. Blood pressures were: right arm, 152 systolic, 80 diastolic; left arm, 170 systolic, 110 diastolic. Legs, no beats heard. No pulsations could be felt over the femoral artery or other arteries of the legs. By roentgenographic examination the heart was somewhat full, but of a normal contour. Several ribs were notched along their inferior borders.

Operation was performed under cyclopropane anesthesia. Exposure was made through the left pleural cavity, posteriorly. A marked degree of aortic obstruction was found (Fig. 7a). A segment of aorta, about 6 centimeters long was mobilized, by dividing the ligamentum arteriosum, two bronchial arteries, and two sets of intercostal arteries. The narrowed portion of the aorta was removed, and the ends of the aorta were anastomosed by a continuous stitch which everted the ends (Fig. 7b). The excised specimen had a lumen which was narrowed to 2 millimeters in diameter.

The postoperative course was uncomplicated except for accumulation of fluid in the left pleural cavity which required one aspiration. Postoperatively, good pulsations can be felt in the legs, and

blood pressures are easily obtainable in the legs. The pressure in the arms gradually diminished over a 10 day period. Hospital discharge occurred on the 17th postoperative day. Blood pressures 1 month after operation were: right arm, 120 systolic, 80 diastolic. Right leg 150 systolic, 90 diastolic.

SUMMARY

A brief résumé is made of the more common abnormalities of the aortic arch and the large arteries which arise from it. Many of the anomalies do not give important symptoms, but others have considerable significance since they: (1) give rise to pressure on the esophagus and trachea; (2) impose a burden on the heart because of an arteriovenous type of shunt; or (3) lead to severe derangements in the circulation because of an obstruction in the aortic pathway.

In the first group of malformations under consideration, the esophagus or trachea (or both) are impinged upon by: (1) a right-sided aortic arch; (2) a double aortic arch; (3) a constricting ring of vessels (or remnants thereof); or (4) by an anomalous right subclavian artery. A right-sided aortic arch cannot be changed by surgical means, but if this abnormally placed structure is attached by a ligamentum arteriosum (or a patent ductus arteriosus) to the pulmonary artery so that this latter vessel is pulled back against the trachea or the left side of the esophagus—then division of the ligament (or the ductus) should give some relief. When a double (or split) aortic arch gives respiratory distress, the patient can be greatly helped by cutting the anterior (left) limb. When dysphagia lusoria occurs from a right subclavian artery (which originates from the left side of the aortic arch), the symptoms can be abolished by dividing the artery so that it no longer presses on the esophagus.

Humans with a patent ductus arteriosus are subject to certain hazards, particularly in mid-life. The shunt can greatly increase the work of the heart and lead to varying degrees of embarrassment or failure. Furthermore, the open ductus is frequently the seat of superimposed bacterial infection. While some individuals live a long and active life with a patent ductus arteriosus—particularly if it is a small one—statistics indicate that the average length of life is little more than half of the normal expectancy. Surgical closure of the ductus has been shown to have very beneficial effects on the cardiovascular apparatus. While surgery can be deferred until symptoms have developed, the technical difficulties of operation at such times is considerable. In contrast, the closure of a ductus at an early age can be accomplished with a negligible risk, and hence we recommend operation in childhood or young adult life before complications have developed. A widening experience in this field makes us feel that ligation of a ductus is usually satisfactory, but that complete division of the vessel is a much superior procedure because it insures complete interruption of the shunt and precludes any possibility of its re-establishment.

Individuals with a high degree of obstruction in the distal part of the aortic arch or in the first part of the descending aorta may live to advanced ages with little or no difficulty, but most of them develop serious or even fatal complications in mid-life. Outstanding among the sequelae of coarctation of the aorta is hypertension which usually appears in the upper part of the body. With this increased pressure may come all of the disorders and dangers of the hypertensive state. Experimental observations show that a section of the upper thoracic aorta can be excised and that the open ends of the aorta can be satisfactorily joined. Such a procedure has been adapted to humans; a narrowed (or completely obstructed) segment of the aorta can be removed and the remaining ends of the aorta can be anastomosed. After performance of this operation, the hypertension is quickly relieved.

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THROMBOPHLEBITIS OF THE DEEP VEINS IN THROMBOANGIITIS OBLITERANS

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IN spite of the fact that thromboangiitis obliterans is known to involve the peripheral great veins as well as the arteries, no cases of this condition have previously come to my attention in which deep thrombophlebitis was the outstanding clinical manifestation. This disease involves the arteries and veins segmentally in adjacent areas. Perivascular infiltration, progressing to fibrosis, later envelops the artery, vein, and accompanying nerve. Except for the occurrence of superficial migratory phlebitis, the clinical manifestation is most frequently one of arterial insufficiency, rather than that of venous obstruction. Homans says, "So far as the veins are concerned, thrombosis is coextensive with that in the arteries. Actually, venous thrombosis is entirely overshadowed by the arterial disease, and so solidly fixed that embolism never occurs. . . . From a clinical point of view, it is only the arterial disease which is of consequence." Collens states, "Deep venous thrombosis will occur, especially with extensive gangrene, but may be unrecognized until amputation is performed; it can then be seen at the site of amputation."

At this hospital 164 patients with thromboangiitis obliterans have been studied. Many of these soldiers were admitted with bizarre and atypical histories, and the diagnosis was established only after investigation of the vascular system. The following case reports of 2 soldiers whose first manifestations of this disease were in the nature of deep thrombophlebitis are examples. The onset was afebrile with no previous history of acute infection or trauma.

CASE 1. This 36 year old soldier of Polish (non-Jewish) parentage gave a history of fatigue and intermittent claudication of the calves of both legs, of insidious onset, for 10 years. He had had mild dyspnea on exertion and intermittent swelling of the left ankle for the previous 2 years. On October 13, 1943, while overseas, without history of injury or antecedent acute illness, he suffered the onset of pain in the left calf and thigh accompanied by swelling from the toes to the lower thigh. There was no chill nor elevation of temperature. He was put to bed with elevation of the limb and given sulfadiazine for 8 days. On November 6 he was permitted to hang the leg over the side of the bed and 5 days later was allowed to be up. Because of precordial pain, electrocardiograms were made on 3 successive weeks. These showed evidence pointing to myocardial infarction. Because of persistent swelling of the left lower extremity, he was again put to bed. With rest the swelling subsided. The patient was thought to have had thrombophlebitis of the left lower leg.

On January 7, 1944, the right lower extremity suddenly became painful and edematous. Roentgenograms were made for evidence of intra-abdominal tumor which was suspected as the cause of the spread of deep phlebitis from the left to the right lower extremity. These were normal. On February 7, 1944, while being studied under the fluoroscope, the patient suffered a sudden, severe pain in the left chest and later coughed up bright red blood. Roentgenograms the following day showed evidence of pulmonary infarction of the right lower lobe. He was put to bed for 3 weeks and when subjectively improved, was moved to the United States.

Upon arrival he was found to have excessive edema of both lower extremities from the toes to the inguinal regions. The heart and lungs were normal. On March 4, 1944, electrocardiograms again showed evidence pointing to an old myocardial infarct of the anterior wall of the heart. The following day bilateral common femoral vein ligation was performed under local anesthesia and segments of these veins were removed for study. Microscopic examination showed pronounced thickening of the walls, marked perivascular infiltration and occlusion of the lumina by organized thrombi. These thrombi contained only a few slit-like channels lined by endothelium, and containing blood. There was slight infiltration of the walls by small round cells and mononuclear leucocytes. Venograms showed the venous return of the left lower extremity to be by way of the lateral circumflex iliac vein. Following healing of the operative wounds, the patient was encouraged to walk about and was transferred to this hospital for further study and treatment on April 22, 1945.

On examination both lower extremities showed massive pitting edema from the toes to the groins (Fig. 1). During dependency there was rubor of both plantar surfaces and toes. There was no pallor on elevation and both feet were normal in color in the

From the Vascular Surgery Center, Ashford General Hospital, White Sulphur Springs, West Virginia.

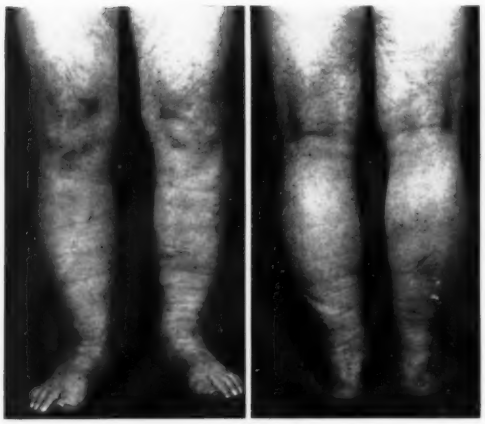

Fig. 1. Case 1. Massive pitting edema from toes to groins of both lower extremities.

horizontal position. There were no trophic changes and no sweating. The dorsalis pedis and posterior tibial pulses were feeble on the left and absent on the right side. The left popliteal pulse was normal, the right feeble. The radial and brachial pulses were equal and normal. Dorsiflexion of the foot (Homans' sign) was negative bilaterally. The dorsal surface of both feet were warm but both plantar surfaces and toes were excessively cold to touch.

TABLE I.—CASE 1. SPINAL ANESTHESIA
VASOMOTOR TEST

Oscillometry

	Control		After spinal	
	Right	Left	Right	Left
Popliteal	2.0 –100 mm.	5.0–100 mm.	2.5–90 mm.	5.0–100 mm.
Tibial	1.0 –100 mm.	2.5–100 mm.	1.5–90 mm.	4.0– 90 mm.
Foot	0.25– 90 mm.	0.5– 90 mm.	0.5–70 mm.	2.5– 80 mm.
Skin Temperatures—Degrees F.				
1st toe	84	84	88	91
2nd toe	83	83.5	88	91
3rd toe	82	83.5	89	91
4th toe	82	83.5	89	91
5th toe	81.5	83.5	89	90.5
Plantar	84.5	85	90	91
Dorsum	87.5	87.5	90	90
Ankle	87	87.5	89.5	90
Midleg	89	89	89.5	90
Knee	86	87	87.5	90
Thigh	87	88	88.5	90

Room temperature, 78°F.

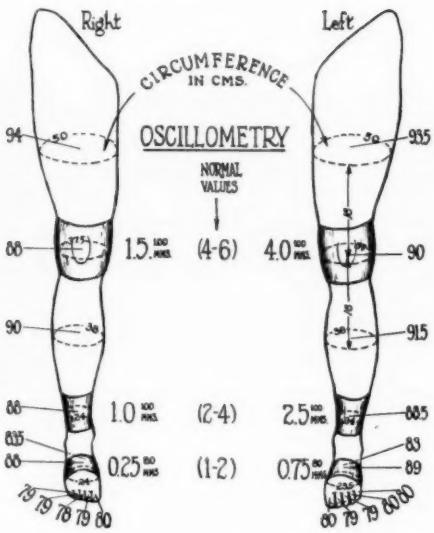

Fig. 2. Case 1. Skin surface temperatures in degrees Fahrenheit. See Table I.

Oscillometric readings were normal at all levels of the left lower extremity except for slight diminution in the foot. The readings of the right side showed a marked diminution at the popliteal, tibial, and foot levels in contrast to the corresponding levels of the opposite side. Circumferences of both lower extremities were symmetrically increased. Skin surface temperatures corresponding to the sites illustrated (Fig. 2) of both lower extremities were symmetrically and pathologically diminished in the toes and plantar surfaces of the feet.

Under spinal anesthesia, readings of skin surface temperature and oscillometry were done after complete motor and sensory anesthesia of both lower extremities was present. Similar readings were done, as controls, prior to the spinal anesthesia. The findings are recorded in Table I. These readings showed no increase in oscillometry with only a moderate rise in temperature on the right side but, on the left side, the oscillometry was normal under anesthesia and the skin surface temperatures reached 91 degrees F. This test showed the typical asymmetry usually found with advance organic vascular disease accompanied by secondary vasospasm. The involvement was confined to the right side. The left side was believed to be functional since the vasospasm was completely relieved during anesthesia. A diagnosis of thromboangiitis obliterans was made on the following findings.

1. Evidence of myocardial infarct in a 36 year old patient.

2. Intermittent claudication in both calves of 10 years' duration.

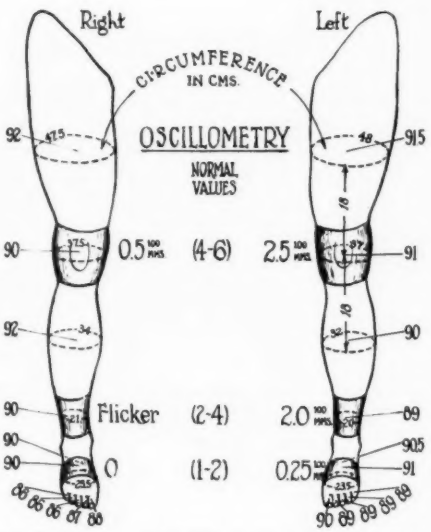

Fig. 3. Case 2. Skin surface temperatures in degrees Fahrenheit. See Table II.

3. Thrombophlebitis of the deep veins of both lower extremities without history of antecedent infection, trauma, or fever.

4. Microscopic changes in segments of excised vein suggestive of thromboangiitis obliterans.

5. Asymmetry of oscillometric readings in both lower extremities despite symmetrical pattern of venous involvement.

6. Rubor on dependency of the toes and plantar surfaces of the feet. These color changes do not accompany the passive congestion of edema in the absence of arterial obstruction.

CASE 2. This 28 year old white soldier of Italian parentage gave a history of fatigue and increasing coldness of both feet and legs of 1 year's duration. The onset was insidious and the symptoms progressive. The feet were cold even in warm weather and frequently kept him awake during the night. He did very little walking because he was employed as a truck driver in the Army. No history of intermittent claudication was given. On March 12, 1944, he experienced sudden pain of knife-like character in the right calf when walking. This pain subsided promptly with rest of the limb. A few days later the right foot and leg became swollen and there was tenderness and pain in the right popliteal region and calf. He reported to a hospital and was treated by rest and elevation of the limb. A diagnosis of thrombophlebitis of the right popliteal vein was made. The pitting edema and the tenderness gradually subsided with rest in bed. During his stay at this hospital a hot water bottle was applied to right calf. Because of anesthesia of the limb the patient sustained a severe burn which was followed by an indolent, necrotic ulcer of the medial aspect of right leg. He was transferred to this hospital June 15, 1944.

Fig. 4. Case 2. Pitting edema from right toes to midthigh. Deep gangrenous ulcer 9 centimeters long and 5 centimeters wide on anteromedial aspect of right midleg.

On examination pitting edema was present from the right toes to the midthigh. A deep gangrenous ulcer 9 centimeters long and 5 centimeters wide was present on the anteromedial aspect of the right midleg (Fig. 4). Dorsiflexion of the right foot (Homans' sign) was positive. Both feet were warm to touch.

TABLE II.—CASE 2. SPINAL ANESTHESIA
VASOMOTOR TEST

Oscillometry

	Control		After spinal	
	Right	Left	Right	Left
Popliteal	0.5 90 mm.	2.75 100 mm.	0.75 90 mm.	3.0–90 mm.
Tibial	Flicker	1.5 –100 mm	0.25 90 mm.	2.5–90 mm.
Foot	0	0.25–100 mm.	Flicker	0.5–90 mm.

Skin Temperatures—Degrees F.

1st toe	77	79	85	91
2nd toe	77	78.5	85.5	90
3rd toe	77.5	78	87	90
4th toe	77	79	85	90
5th toe	78	79	90	91
Plantar	82	83	90	90.5
Dorsum	82	83	86	90
Ankle	85	84	88	89
Midleg	89	88.5	88	88
Knee	87.5	87	89.5	89
Thigh	90	89.5	91	90

Room temperature, 78° F.

On dependency the dorsal and plantar surfaces of the left foot were cyanotic and the toes were ruborous. The right foot was ruborous from the midfoot to the toes. On elevation cadaveric pallor was observed on plantar surface of the right foot and toes. The left side was normal. The dorsalis pedis, posterior tibial, and popliteal pulses on the right side were absent. The left dorsalis pedis and posterior tibial pulses were feeble and the popliteal pulse was weak. Oscillometric readings on the right side were barely perceptible at the tibial and popliteal levels and zero at the foot. The readings on the left side were diminished at the popliteal level, tibial level and the foot. The skin surface temperatures were within normal limits on both sides but 2 to 3 degrees F. higher in the left toes than the right (Fig. 3). Comparative circumferences showed the right leg and ankle to be greater than the left.

Under spinal anesthesia, readings of skin surface temperature and oscillometry were done, after complete motor and sensory anesthesia was present. Control readings were recorded prior to the spinal injection. The findings are recorded in Table II. The test showed advanced obliterative vascular disease of the right femoral artery. The left side showed early obliterative arterial disease in the foot. Severe secondary vasospasm was found on both sides. These findings support a diagnosis of thromboangiitis obliterans involving the major arteries of right lower extremity and distal arteries of left foot.

On the basis of the criteria necessary for a diagnosis of thromboangiitis obliterans, this disease was established in the 2 cases reported. The importance of these case reports lies not in establishing a diagnosis of thromboangiitis obliterans alone, but also in recording the cardinal symptoms which brought about the hospitalization of these patients. Both patients gave a history of insidious and progressive arterial incapacity going over a period of time prior to the onset of the signs and symptoms which precipitated their hospitalization. In neither instance was the incapacity severe enough to excuse them from military service. However, the appearance of spontaneous, afebrile, deep thrombophlebitis without apparent systemic disease, infection, or trauma brought about their hospitalization.

In the first case, the patient suffered arterial involvement not only of his right lower extremity but also of his myocardium. The latter was evidenced by electrocardiographic changes. The deep thrombophlebitis was the factor that led to his hospitalization. The occurence of pulmonary infarction, secondary to thrombophlebitis, caused by thromboangiitis obliterans, is rare, and therefore, is reported in this paper. Biopsy of the veins confirmed the diagnosis.

In the second case, the patient's peripheral vascular symptoms were obscure until involvement of the right femoral vein with clinical manifestations of deep thrombophlebitis appeared. Anesthesia in the skin of the right leg was severe enough to cause a third degree burn by a hot water-bottle followed by secondary indolent ulcer. This is not uncommon in the ischemic limb. His treatment, at time of admission to hospital and thereafter, was chiefly concerned with the deep thrombophlebitis.

The diagnosis of thromboangiitis obliterans was made on the basis of the findings of diminished and asymmetrical oscillometric readings in the lower extremities; the presence of dependent rubor, and plantar pallor on elevation; absent unilateral pulses in the feet, and diminished skin temperatures. The persistence of abnormal oscillometry with increase of skin surface temperature in the feet after relaxation of the sympathetic nerves under spinal anesthesia implies the presence of organic vascular disease.

SUMMARY AND CONCLUSIONS

1. The signs and symptoms of deep thrombophlebitis may be present as a clinical symptom in thromboangiitis obliterans.

2. Pulmonary infarction may result from thrombosis of the great veins involved in the process.

3. Every case of afebrile idiopathic deep thrombophlebitis in a young patient must be considered a possible instance of thromboangiitis obliterans and the arterial tree carefully investigated for further vascular involvement.

4. The presence of passive congestion in a limb secondary to venous obstruction may cause a reactive hyperemia which temporarily may mask some of the signs and symptoms of arterial insufficiency.

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RELATIVE SURGICAL CURABILITY OF CERTAIN GROSS TYPES OF GASTRIC CARCINOMA

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A STUDY of the general statistics presented in 239 cases of gastric carcinoma is the basis of this paper. The paper does not discuss the general curability of gastric carcinoma but deals solely with the relative curability of certain types of this disease.

The most beautiful synopsis of all aspects of the prognosis of gastric carcinoma is found in the admirable book of Livingstone and Pack. The analysis of their enormous material is profound and cannot be successfully attacked. It may be doubted, however, whether all conclusions arrived at by the authors are equally valid. I refer especially to two conclusions. The first one is the statement: "Gastric surgery does not now, nor is it likely in the future, to prove a satisfactory answer for more than the smallest number of patients." This statement is undoubtedly correct for the present time, but it is possible that better conditions may be hoped for in the future. Attempts at mass examinations of symptom free people have been made. Attempts also have been made to discover early and to observe precancerous conditions; the initial research possibly may not be too successful, but there is no reason to lose courage and to discontinue such attempts.

The second conclusion of Livingston and Pack, the validity of which seems questionable, is the recommendation of resection in as many cases of gastric cancers as possible. This recommendation is given in spite of the pessimistic attitude mentioned. The patient with gastric carcinoma is lost if resection is not performed. Resection alone provides hope. Certainly, it is unjustifiable not to attack surgically the neoplasm in any patient who may be saved. However, in the long run, the recommendation of more and more indiscriminate resections is scarcely the best way to obtain better results. The authors may have overlooked the fact that large numbers of resections will not only increase the number of surgical successes—cures—but will increase even more the number of surgical failures; as stated before, only a very small number of patients can be cured, so the number of surgical failures will grow overwhelmingly. These failures will discourage the laity, with the result that instead of early surgery being done more often, less and later surgery will be performed—a development to be prevented under any circumstance. Therefore, it is imperative to find ways by which, in a given case, a reasonable prognosis can be made before operation.

It is well known that the degree of malignancy in gastric carcinomas, as in other carcinomas, varies. Attempts have been made to express, by means of the microscopic grading of these tumors, the degree of malignancy and the surgical prognosis. Grading, by microscope, however, is not too reliable. It is true that grades 1 and 2 gastric carcinomas give a much better prognosis than do grades 3 and 4 tumors (3): but grades 3 and 4 carcinomas can be cured with rather great relative frequency. On the other hand, a certain number of grades 1 and 2 tumors prove to be very malignant clinically. Furthermore, microscopic grading cannot be accomplished before operation. Gastroscopic biopsy alone would make such grading possible. While this procedure at present does not yield satisfactory results, it may be developed later. Even then, the finding of a grade 3 or 4 carcinoma would not justify abandonment of surgery.

Another and perhaps better way would be to base the prognosis and the therapeutic procedure on *gross types* of gastric carcinoma. Borrmann has described 4 gross types; it was not his intention, however, to correlate the gross type with the prognosis. The classification presented is based only on gross appearance of the tumor (Schindler, 6; Bockus).

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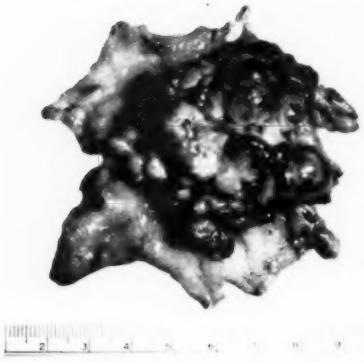

Fig. 1. Carcinoma, type I. Resected specimen. A polypoid tumor protrudes into the lumen of the stomach. The tumor is sharply limited everywhere. Its edge is partly mushroom-like and overhanging. In this case its surface is ulcerated but ulceration is not the rule in type I carcinoma.

THE GROSS TYPES

Type I in this classification is the sharply limited polypoid tumor which projects hemispherically into the lumen of the stomach. It often looks like a mushroom with overhanging edges, its surface presenting numerous nodes and nodules which usually are of different sizes. Ulceration of the surface develops late. The mucosa surrounding this type of tumor is often thoroughly atrophic. Its incidence is about 2.9 per cent of all gastric carcinomas.

Type II is a sharply limited tumor also. It consists of an ulcer surrounded by an elevated wall. This wall has a steep slope toward the surrounding mucosa and is sharply demarcated all around. The floor sometimes shows necrotic material of various colors. The wall may be smooth, or more frequently it is nodular and contains shallow erosions. Its dark red color then is in marked contrast to the pale color of the surrounding mucosa. Its incidence is 17.6 per cent.

Type III is easily confused with type II. It also consists of an ulceration and of a wall. But the wall does not surround the whole circumference of the ulcer. The ulcer, sharply limited on one side, blends diffusely at some point with the neighboring mucosa which is diffusely infiltrated. Therefore, this is not a sharply limited but an infiltrative type of carcinoma. Its incidence is 16.3 per cent.

Type IV comprises the diffusely infiltrative tumors. No sharp limit is found anywhere; sometimes the entire stomach may be infiltrated. Within this infiltration ulceration may develop shallow or deep ulcers. The incidence of this type is 63.2 per cent.

It seems that a tumor of a given type never changes from this type however large it may become. A type II carcinoma remains sharply limited even if it finally involves the entire stomach; a type IV carcinoma is diffusely infiltrative when it is only a few millimeters in diameter. Still more remarkable is the fact that the microscopic structure of tumors of the same gross type may vary markedly. It might be expected that the microscopic structure would determine the gross growth, but this is not so. The sharply limited types I and II may be adenocarcinoma, colloid carcinoma, or medullary carcinoma, microscopically. The infiltrative types often are medullary or scirrhous carcinomas, but they may be colloid carcinomas or differentiated adenocarcinomas as well. What then causes the different types? The answer is not known. There are obviously two possible explanations: (1) that there are features of the microscopic structure responsible for the gross growth which we do not yet recognize; (2) that not the tumor itself, but the reaction of the surrounding tissue is responsible for the gross development of the tumor.

Early in my experience it seemed to me (6) that the prognosis in the sharply limited types I and II differed from that in the infiltrative types III and IV. In order to substantiate this belief care was taken to type as many as possible of the available cases of carcinoma, especially when resection had been carried out. Specimens obtained by resection of tissue usually make reliable typing possible. However, in a number of cases, pathological material could not be obtained, and the gastroscopic or x-ray evidence as to the type involved was not considered to be sufficiently accurate. Such cases were registered as "type not known."

From the previously mentioned incidence it will be seen that statistically the sharply limited types I and II constitute approximately 20 per cent of all cases of gastric car-

Fig. 2. Carcinoma, type II. Resected specimen. The tumor is rather small. A large ulcer is surrounded by a broad wall which is sharply limited at all points. There is no trace of infiltration. In some cases the wall may be thinner; it may even be partly absent. Characteristic is the sharp limitation of the lesion.

Fig. 3. Carcinoma, type III. Resected specimen. At the lower margin of the ulcer there is a very flat wall. In the right upper quadrant the carcinoma invades the gastric mucosa diffusely and the ulcer floor blends imperceptibly with the surroundings. In other cases the wall is much higher and better defined. Yet, if there is any infiltration instead of sharp limitation the tumor must be classified as type III.

cinoma; that the infiltrative types III and IV constitute 80 per cent of all cases. If the prognoses in these forms were approximately equal, this ratio of 20:80 or 1:4 might well be expected to be found at any stage of the observation.

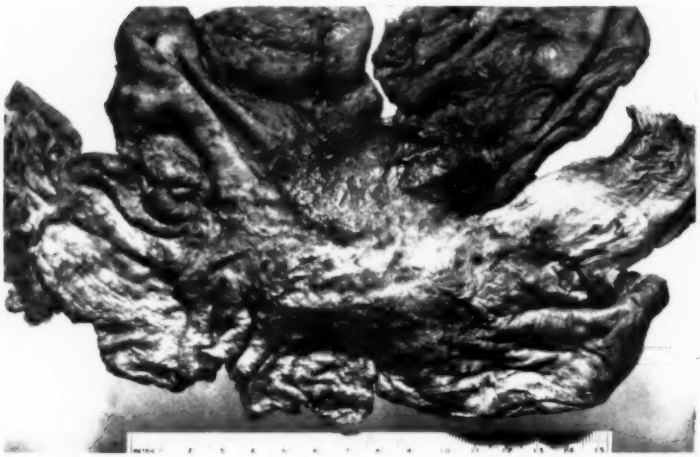

Fig. 4. Carcinoma, type IV. Postmortem specimen. There is diffuse infiltration along the lesser curvature with ulcer formation. Nowhere is any kind of limitation apparent.

ANALYSIS OF 107 RESECTED CASES

A total of 239 gastric carcinomas was analyzed. Surgery was done in 167, but only in 107 was resection for cure carried out (palliative resections are not contained in this figure). The data in these 107 resections form the basis of comparison of the types of gastric carcinoma.

Of 107 gastric carcinomas resected the gross type was not given in 20 but was known in 87 (see Table I). Eight belonged to type I, 22 to type II, 20 to type III, and 37 to type IV. In 40 cases the course was unknown; either no follow-up was possible or the follow-up did not last long enough. Thus there remain 67 cases, of which the course was known. Five belonged to type I, 12 to type II, 14 to type III, and 25 to type IV; but in 11 cases the type was unknown. In these 67 cases the follow-up was sufficient. But only the 56 cases with known types contribute to the final results of this study. Twenty-five of the 67 died postoperatively, and of these none belonged to type I, 5 to type II, 5 to type III, and 12 to type IV; in 3 the type was unknown. If again the unknown types are omitted, then there were 34 survivors of gastric resection with known course and known type: 5 belonged to type I, 7 to type II, 9 to type III, and 13 to type IV. (In Table I, one may also find the "possible cures," which are obtained when the postoperative deaths are subtracted from the total number of resections.)

Table I also contains the statistics on surgical failures: those cases in which the death was actually observed and those cases in which recurrence was observed clinically and which usually were seen in the last stage of the disease. It will be noted that in all 8 cases of "unknown type" in which the course was known the patients succumbed; but one of them died from pneumonia, and as there was no autopsy it cannot be stated whether or not there was recurrence. The other 7 patients, however, died from recurrence. Of the 5 type I carcinomas, 2 died before the end of the 3d year. One of them died from heart disease after 2 years, 3 months; autopsy was performed and failed to reveal any sign of recurrence. The other type I case had had a polyposis *en nappe* (at gastroscopy 26 single adenocarcinomas were counted) and one of the polyps close to the cardia had developed into a sharply limited type I ulcerated carcinoma. The surgeon, believing that he was dealing with a benign tumor, made only a local excision. Half a year later the patient developed a carcinoma of the upper esophagus and succumbed quickly. Only 4 weeks before the death a successful gastroscopy was carried

TABLE I.—DISTRIBUTION OF GROSS TYPES IN 107 CASES OF RESECTED GASTRIC CARCINOMA

Gastric resections	Types				Unknown	Total
	I	II	III	IV		
Total cases	8	22	20	37	20	107
Course unknown	3	10	6	12	9	40
Course known	5	12	14	25	11	67
Postoperative deaths	0	5	5	12	3	25
Possible cures	8	17	15	25	17	82
Follow up in postoperative survivors	5	7	9	13	8	42
Failures: Death observed	2"	2*	3	6	6†	19 } 35
Failures: Recurrence observed	0	2	6	6	2	16 }
3 year survivors†	(3)	(4)	(1)	(1)	(0)	
3 year cures	3	3	0	1	0	7
5 year cures	2	2	0	0	0	4

†The cases of 3 year cures are contained in line showing 3 year survivors, also; 2 of the survivors are found also among the recurrences.
"One patient died from heart disease—autopsy showed no recurrence. One patient died from carcinoma of the upper esophagus.
*One patient died from coronary occlusion, 2½ years postoperatively; at autopsy no recurrence found.
‡One patient died from pneumonia.
All other patients died from recurrence of the carcinoma.

out (in spite of the obstructing esophageal tumor), and no sign of recurrence was seen. No permission for autopsy could be obtained.

Of the 7 type II cases followed, 2 patients died before the end of the 3d year and in 2 others recurrence was observed. One of them lived longer than 3 years, however; this was a 3 year survivor, but not a 3 year cure. In 1 of the 2 cases in which the death was observed patient died from coronary occlusion after 2 years and 4 months. An autopsy was performed and no recurrence was present.

Of the 9 type III cases followed, all had recurrences of the carcinoma. One of them was a 3 year survivor. There was no observed cure.

In 6 of the type IV cases followed, death from recurrence was observed. In 6 others, the presence of recurrence was stated clinically. But 1 patient survived. He was seen alive and apparently healthy 3 years, 4 months after the operation.

If then we are to compare the types of the 7 remaining 3 year cures, we find that 3 of them belonged to type I, 3 to type II, none to type III, and 1 to type IV. If we combine the types I and II to the group of sharply limited carcinomas and types III and IV to the group of infiltrative tumors, then we should expect, as shown previously, that the ratio would be 1:4, if both groups would have equal chances for cure. Instead, we find a ratio of 6:1. A patient having a sharply limited type of gastric carcinoma had a 24 times greater chance for a 3 year cure than a patient having an infiltrative type of tumor so far as these data are concerned.

Only 4 cures of 5 years' duration were known in this sampling of data but it is noticeable that all 4 of them belonged to the sharply limited group (type I–II), none to the infiltrative group!

In Table II attempt has been made to express the results obtained by percentage figures. Again, it should be borne in mind that an incidence ratio of 1:4 between the sharply limited and the infiltrative forms should be expected. The distribution of types in 87 cases of gastric resection in which the type was determined was as follows: 34.5 per cent of all cases belonged to types I–II, 65.5 per cent to types III–IV. The ratio, instead of the expected 1:4, is 1:1.9. Sharply limited tumors would appear to be resectable almost twice as often as the infiltrative tumors.

The ratio of postoperative deaths to the number of resections for the different types is also given in Table II; the postoperative mortality is 16.7 per cent for types I–II, but 29.8 per cent for types III–IV. Here a death ratio of 1:1 would be expected on the assumption of equal postoperative mortality. In

TABLE II.—PERCENTILE DISTRIBUTION OF GROSS TYPES OF GASTRIC CARCINOMA

	Type I	Type II	Type III	Type IV
Distribution of types in 87 cases in which the type was determined	8 / 30 = 9.2%	22 / 34.5% = 25.3%	20 / 57 = 23%	37 / 65.5% = 42.5%
Postoperative deaths	0 / 5 = 0%	5 / 16.7% = 22.7%	5 / 17 = 25%	12 / 29.8% = 30.8%
Known 3 year cures of all originally typed cases	3 (of 8) / 6 (of 30) = 37.5%	3 (of 22) = 13.6% / 20%	0 (of 20) / 1 (of 57) = 0%	1 (of 37) = 2.7% / 1.8%
3 year cures of all typed patients with known course	3 (of 5) / 6 (of 17) = 60%	3 (of 12) = 25% / 35.3%	0 (of 14) / 1 (of 39) = 0%	1 (of 25) = 4% / 2.6%
3 year cures of followed-up postoperative survivors	3 (of 5) / 6 (of 12) = 60%	3 (of 7) = 43% / 50%	0 (of 9) / 1 (of 22) = 0%	1 (of 13) = 7.7% / 4.5%
3 year cures of followed-up postoperative survivors	2 (of 5) / 4 (of 12) = 40%	2 (of 7) = 28.6% / 33.3%	0	0

stead we find the ratio to be 1:1.78. The relative postoperative mortality of the infiltrative types is 1.78 times higher than that of the sharply limited types.

Earlier in this paper, when the absolute figures were discussed, it was stated that the ratio of types I–II 3 year cures to types III–IV 3 year cures was found to be 6:1 instead of the expected 1:4. But for statistical purposes such a simple comparison seems scarcely permissible. The relation between the types at different stages of the observation varies, and it is perhaps fairer and more logical to relate the 3 year cures to the number of each type observed at the various stages. This attempt has been made in Table II. We may compare the 3 year survivors with all originally typed cases. There were originally 30 cases of types I and II and 57 cases of types III and IV. But of the 30 types I and II cases, 6 had a 3 year cure representing 20 per cent. Of the 57 types III and IV cases only 1, or 1.8 per cent, was a 3 year cure. These percentages 20:1.8 equal 11:1. Thus of all originally typed resected cases, a type I–II patient had an eleven times greater chance for a 3 year cure than did a type III–IV patient. It must be recalled that these ratios are based on relatively small samplings. The problem of the reliability of the findings is discussed in a statistical note appended to this paper.

We may choose to relate the final known 3 year cures to all typed patients with known course (Table II). Here the postoperative mortality is included, and since it is higher in types III and IV than in types I and II, the results become still more unfavorable for the infiltrative types. In 17 type I–II patients and in 39 type III–IV patients the course was known. The 3 year cures in types I–II (6) constitute 35.3 per cent; those in types III–IV (1), only 2.6 per cent. The ratio is 13.5:1. Analyzing all typed patients with known course we find that types I–II patients have a 13.5 times greater chance of a 3 year cure than have types III–IV patients.

Finally it may be interesting to eliminate the postoperative deaths and to compare the final results with those postoperative survivors who had a sufficient follow-up. Twelve postoperative survivors of types I–II were followed up and 22 postoperative survivors of types III–IV. The 6 types I–II 3 year cures constitute 50 per cent, the one types III–IV 3 year cure constitutes 4.5 per cent of these survivors. The ratio is 11:1. If we analyze only the postoperative survivors, the types I–II patients still seem to have an eleven times greater chance of a 3 year cure than do the types III–IV patients.

Whichever of these comparisons is chosen, it becomes apparent that a patient having a sharply limited gastric carcinoma has a 10 to 13 times greater chance of a 3 year cure when resection is performed than has a patient with an infiltrative carcinoma.

No such consideration is possible for 5 year cures. Only patients with sharply limited tumors survived. And so far as these few data constitute a criterion it would appear that in infiltrative gastric carcinoma no five year cure is possible.

THE TYPE I GROUP

Of special interest are the type I patients. It is the smallest group, therefore most subject to statistical error. Yet, the results are remarkable. There was no postoperative death and of 5 cases followed, 3 had a 3 year cure. Of these, 2 were still alive after 5 years. Neither case, the death of which was known, died from a recurrence of the original tumor: one of them died from a carcinoma of the upper esophagus, the other one from heart disease, autopsy failing to show a recurrence. The original tumor of one of the 5 year survivors was not entirely restricted to the stomach wall; carcinoma cells and nests were found in the small omentum close to the stomach. Furthermore, this tumor looked microscopically rather malignant and was graded as grade 3; nevertheless this patient belongs to the 5 year cures!

GRADING OF THE CURED CASES

Though no lengthy description of microscopic grades in this material shall be given, it may be interesting to compare gross types and microscopic grades in the 3 year and 5 year cures (See Table III). The 3 type I tumors are distributed equally among grades 1, 2, and 3. Of the 3 type II tumors only 1 belonged to grade 2, the other 2 to grade 4. The one cured type IV tumor belongs to grade 3. Of the four 5 year cures 2 belonged to grade 2, one to grade 3 and one to grade 4. Since grade 1 and grade 2 are very rare this table confirms the observations of the Mayo Clinic that grade 1 and 2 tumors have an excellent chance to be cured. On the other hand it shows that the clinical curability follows less exactly the microscopic grades than it does follow the gross types.

DISCUSSION

Of 7 observed 3 year cures of resected gastric carcinomas 6 cases belonged to the sharply limited types, only 1 case belonged to the infiltrative types. The observed four, 5 year survivors all belonged to the sharply limited types. If the observation of this series could be generalized, important practical conclusions could be drawn. But it is obvious that the data are too limited. The original 239 cases yielded only 7 observed 3 year cures. However, in 48 cases the course was not followed, and in these there may be about as many 5 year cures as are in the 42 cases with known course after resection and postoperative survival. Eight long term survivors of 239 cases are about 3.3 per cent. Livingston and Pack, analyzing important and extensive statistics of long term survivors, showed that these "were scarcely more than 3 per cent of those having gastric cancer." However, for a reliable comparison of the incidence of gross types, typing of such large numbers of survivors would be much preferable to the limited data presented here. Percentage of cures seems less important for our problem than the comparison of incidence of gross types within the cures. If such typing would be regularly undertaken in institutions treating large numbers of patients, then again 8 to 10 years must elapse before such material could be evaluated. In contrast to grading of tumors, where the conserved microscopic material can be used, no work-up of former material is possible for the determination of gross types. Nowhere are all resected specimens of gastric carcinoma conserved without mutilation. Only good photographs could be helpful. The gross descriptions of the resected material practically never are worded so that they can be used for the determination of types.

I have come to the decision to publish the account of this small number of cases because

TABLE III.—TYPES AND GRADES ON 3 AND 5 YEAR CURES

	Grade 1	Grade 2	Grade 3	Grade 4	Totals
Type I	1	1*	1*	–	3
Type II	–	1*	–	2(1*)	3
Type III	–	–	–	–	–
Type IV	–	–	1	–	1
Totals	1	2	1	3	

*=5 year cures

I hope that the startling results may be a stimulus for the continuation of similar research. In my opinion, even single cases of long term cures are interesting, if the gross type can be stated beyond doubt. And we certainly are looking anxiously for the publication of 5 year cures in infiltrative forms of gastric carcinoma. Although 3 year apparent cures by no means prove a real cure (Nathanson and Welch), even the publication of several cases of 3 year cures in infiltrative forms would seem worthwhile because they would contrast sharply with the one case from these data.

It is not my impression that the average life duration of the patient with an infiltrative carcinoma is shorter than that of a patient with a sharply limited form, if no operation is performed. I have no statistical material to prove this point. Not rarely patients with diffusely infiltrative carcinomas are seen who live relatively long, about 3 years, not uncomfortably. On the other hand, sharply limited tumors, especially of type II, may be seen to grow rapidly and terminate the life of their bearers in a few months. All conclusions one wishes to draw from the materials presented can possibly refer only to the surgical prognosis.

If the results obtained here should prove correct in 10 years, then they would influence the treatment of gastric carcinoma greatly. Then obviously one should try to diagnose the favorable limited types of gastric carcinoma as early as possible, and one may become reluctant to attack infiltrative forms surgically unless the respective tumor is very small.

At present it is much too early to draw any conclusions; but the question may come up: how can we recognize the different types without exploratory laparotomy? Whichever method we may use we will be careful never to make the diagnosis of an unfavorable infiltrative type as long as there is still the remote possibility of a favorable limited type. However, by x-ray examinations diffuse infiltration can often be stated without ambiguity, and a wall surrounding the entire lesion sharply will often permit the diagnosis of a type II carcinoma. Relief technique is indispensable for such diagnoses (8). Often then the Carman meniscus sign will be found which is almost pathognomonic for the favorable type II, and only rarely will be seen in the unfavorable type III.

Gastroscopically the types can be recognized often beautifully. Great care, however, should be exercised. The gastroscopist must not dare to diagnose the type, if he has not seen the entire circumference of the tumor. Schindler and Lètendre (7) published reports of 74 cases in which gastroscopic typing was checked surgically. Three cases were believed to belong to type I; but one of them proved at surgery to be a type II carcinoma. Fifteen cases were believed to belong to type II at gastroscopy. This was correct in 14 cases, but 1 case proved to be an infiltrative type IV carcinoma. In 20 cases, a type III tumor was diagnosed. In 19 cases this diagnosis proved to be correct, but one case was found later to be a favorable type II. In 36 cases a diffusely infiltrative type IV carcinoma was diagnosed, but this diagnosis proved to be incorrect in no less than 7 cases. In 3 cases a type III carcinoma was found in the gross specimen. But in 4 cases a type II carcinoma proved to be present, and this mistake is obviously important. This experience led to the conclusion to be careful with the gastroscopic typing of gastric carcinoma. Generally it can be stated, however, that with combination of x-ray and gastroscopy a rather satisfactory typing of gastric carcinoma is possible before surgery.

SUMMARY

1. In 7 cases of gastric carcinoma a 3 year cure was observed, and in 4 of them a 5 year cure. Of the 7 observed 3 year cures, 6 belonged to the sharply limited gross types, (types I-II) and only 1 to the infiltrative types (types III-IV). After 5 years only 4 patients having had a sharply limited carcinoma (types I-II) were known to be alive.

2. These data are too limited to permit any final conclusions, but the results of the analysis should stimulate further research about the incidence of the gross types of gastric carcinoma among the long term postoperative survivors.

3. By combination of x-ray and gastroscopy usually the gross type of a gastric

carcinoma can be identified reliably before operation.

Statistical Note. The number of cases surviving for 3 or more years is small and the total sampling of cases of known type and course is not large. The problem of the statistical reliability of the findings is therefore one of paramount importance in the final interpretation. If the analysis is limited to the 56 cases for which type and course are known, the following simplified table can be described:

	Types I-II	Types III-IV		
3 year cures	6	1	7	X^2 (corrected for continuity by Yate's method) = 8.8
those not cured	11	38	49	P .01
	17	39	56	

The value of the corrected X^2 for one degree of freedom is such as to indicate that there is less than one chance in one hundred that the relationship indicated in the table is the result of random factors. It is unlikely then that the findings which favor the greater probability of cure for cases classified as types I and II as compared with those in types III and IV could have been produced by chance. The major conclusions of the study appear, therefore, to be statistically reliable.

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MANAGEMENT OF PLASTIC MAXILLOFACIAL WOUNDS IN AN EVACUATION HOSPITAL

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THIS report is based on the case records of 1148 patients treated by a plastic maxillofacial team during approximately one year's work in a 400 bed evacuation hospital where the incidence of plastic maxillofacial injuries was 7.1 per cent. All of these patients, except 79 burn cases, received an anesthetic. Of the patients under consideration, 770 had only maxillofacial wounds but the remainder, or 32.2 per cent, had both maxillofacial and other injuries which were also operated on by the team. A total of 2,350 operative procedures were performed upon the reported group: 1,927 plastic maxillofacial and 423 additional operations.

GENERAL CONSIDERATIONS

On each successive opening of the hospital this team represented the most forward maxillofacial personnel. Therefore more than 90 per cent of the patients were seen within 20 hours after injury. The peak load always occurred during the first few days of each set up. Since immediate treatment was an urgent necessity, it seems worth while to review salient features in the plan used in caring for the injured, preliminary to surgery.

Preliminary care. First, it was found most advantageous for the plastic maxillofacial team to do the triage on patients with plastic maxillofacial injuries. This procedure (1) permitted a continuous flow of patients to the operating table, alternating the severely injured with the less severely injured so that the time necessary for the preparation and anesthetizing of the former could be utilized in the treatment, under local anesthesia, of the latter; (2) established priority of cases for surgery; (3) took cognizance of patients in shock from anoxia and requiring establishment of an open airway before they could become surgical risks; and (4) permitted recognition of those cases in which pressure dressings did not control hemorrhage.

Second, to eliminate unnecessary handling, patients were sent to x-ray tent, returned to preoperative or shock tent, and later taken to surgery without being removed from their litters. During times of peak load no baths were given before patients reached the operating tent, since exposure in an improperly heated tent would only increase their discomfort and hazard.

Preoperative medication and therapy were administered by preoperative or shock personnel after the patient had been seen by a member of the plastic maxillofacial team. Atropine, grains 1/150 to 1/100, was given to every patient. Morphine was or was not given, depending on the amount administered by forward medical units. As has been pointed out by others, mere lack of signs of morphine effect is no criterion for the administration of more of the drug, since absorption may have been delayed. A patient who is in more or less shock and exposed to the cold may show no signs of morphinism for as long as 9 hours after subcutaneous administration of ½ grain of morphine.

Careful attention to the state of the patient determined whether or not blood, plasma, or crystalloid fluids should be used. One death (see Case 1 under "Deaths and Their Causes") can probably be attributed to the lack of such supportive treatment.

Third, in the operating tent we preferred to use a master instrument table with two operating tables, thereby reducing waste in sterile instruments and consequently saving time.

Fourth, we found compelling reasons for using a general anesthetic in the majority of cases. It was impossible to give these patients adequate surgical preparation under local anesthesia, for the wounds were filled with

caked sulfanilamide powder, dirt, and dried blood so that it was necessary to scrub the area with white soap and liberal quantities of water and to irrigate the wounds with sterile saline solution. The high percentage of patients who had multiple injuries requiring surgical treatment presented another objection to the use of local anesthesia.

After the patient was surgically prepared and draped, examination was completed and the findings correlated with the roentgenograms to permit a planned operation.

Surgical care. Careful and adequate débridement was our rule. "Débridement," as used in this paper, comprehends the removal of all devitalized tissue, detached bone, and foreign material, including missiles. Aided by adequate roentgenological localization we were able to remove all foreign bodies in almost every instance. Such removal could be accomplished with greater ease and profit at this stage than at a later operation, because the wounds were already open and exposed to their depths for excision, and the paths of the missiles were still unabridged.

In our hands, primary closure of battle wounds of the face and neck was consistently achieved if operation were performed within 20 hours after injury. Seldom were we confronted with a patient seen too late for the successful performance of primary definitive surgery, other than reconstructive. Since it was a policy to evacuate none except the slightly injured under a minimum of 5 days postoperatively, and since some patients who presented special problems were held as long as 10 days, it is possible to speak with some degree of accuracy regarding the incidence of postoperative infection: superficial or stitch infection occurred in less than 5 per cent of the patients; no cases of cellulitis developed in the reported series.

Primary removal of foreign bodies was responsible, in great measure, for this low incidence of postoperative infection. Observations made here point to the conclusion that nowhere else does careful, adequate, and early débridement pay better dividends than in plastic maxillofacial surgery. In contrast, those who reached the general hospital without receiving definitive treatment at a more forward installation had, by the time of their admission, such a degree of infection that a prolonged period of treatment was necessary. This resulted in not only an extended period of hospitalization, but, more important, in definite scar formation and contracture as well. It became evident that maxillofacial injuries should receive the benefit of definitive surgery done at the most forward element possible.

TABLE I.—CAUSATIVE AGENTS

	Cases	Total
Gunshot wounds		
Rifle	147	
Machine gun	24	
Pistol	11	182
Shell wounds		
High explosive	626	
Mortar	26	652
Bomb wounds		
Aerial	19	
Grenade	9	
Mine	87	115
Nonbattle casualties	91	91
Burns		
Petrol	61	
Flash	40	
Phosphorus	7	108
Total		1148

WOUNDS TREATED

Soft tissues of the face. It would be difficult to exclude from this discussion the treatment of skeletal injuries to the face, because trauma of the supportive skeletal structure accompanies all except simple lacerations and abrasions in this area. Fractures with displacement need to be reduced and supported. If that can be accomplished, then accompanying injuries of the soft tissues can be treated as if the skeletal structure were undamaged. In many instances repair of the soft tissues gives adequate support to the fracture. When the fracture is reduced and the tissues sutured in their normal relationship an important step in the prevention of infection has been achieved.

Our usual procedure was as follows: The patient was given endotracheal ether with Flagg apparatus. The face was scrubbed with white soap and water and then shaved, though if the eyebrow were involved that area was prepared by clipping so that the normal hairline might serve as a guide in

TABLE II.—WOUND TYPE (ARMY CLASSIFICATION)*

	Cases
Penetrating	512
Perforating	212
Lacerating	184
Burns	108
Blast (or tattoo)	96
Gutter	36
Total	1148

*In cases with multiple wounds only the major wound is listed.

approximating skin edges. The face was then scrubbed again with white soap and water, dried with sterile towels, and draped. Careful débridement was accomplished. The wound was irrigated with sterile saline solution. Fractures were reduced. If the maxillary sinuses were involved a nasal antrotomy was done, followed by packing with vaseline gauze. Frequently packing served the further purpose of supporting a fractured zygomatic malar. Hemostasis was meticulously effected. The deeper structures were approximated in their normal relationship with interrupted No. 0000 catgut or silk sutures, obviating all dead space. Skin margins were approximated with vertical mattress sutures of nylon or silk.

The question of tissue loss is an interesting one. There is no war wound of the face in which tissue loss is not represented, though it reaches its maximum in the avulsive type of injury. However, the degree of loss nearly always seems greater than it actually is. Often in reconstructing a severely injured face one is surprised to find almost all of the soft tissue present. The defect appears greater because of the distortion.

Blast or tattoo injuries. Multiple foreign bodies, powder, tar, gravel, dirt, and small bits of metal imbedded in the skin and subcutaneous tissues as the result of a nearby explosion of land mine, bomb, or shell were among the tattoo injuries. Surgical care of such injuries was tedious and time consuming. While the patient was under anesthesia, the area was thoroughly scrubbed with a stiff brush, soap and water, and then cleansed with ether as a solvent for tar and grease. All residual particles and fragments were carefully picked out with a curette or the point of an abscess knife.

Enucleations. This plastic maxillofacial team performed 51 enucleations, but only in those cases in which penetrating or perforating wounds of the eye were associated with collapse of the globe, as all other injuries of the eye were cared for by the ophthalmologist. When dealing with a badly mutilated eye we were careful to remove all retinal tissue, to prevent sympathetic ophthalmitis.

Eyelids. Of the 69 injuries to upper and lower eyelids, 17 were of such severity as to require reconstructive surgery. Treatment in the latter group consisted of (1) thorough cleansing of the wound, (2) protection of the cornea, and (3) early evacuation.

The remainder of these injuries were primarily sutured. Wounds that extended through the whole thickness of the lid were closed in two layers. The sutures of the conjunctival layer were brought out in the conjunctival sac and the edges of the cutaneous layer were loosely approximated, the sutures being tied on the surface. Due care was exercised to approximate accurately the borders of the lid.

External ear. We operated on 56 patients who had injuries of the external ear. Of this group 20 represented varying degrees of tissue loss and 2 patients had complete avulsion. Where the loss of tissue was not too great we effected reconstruction and primary closure. We débrided and excised to the point where accurate approximation of the wound margins was possible and then held the margins in place with interrupted nylon sutures supported by folded gauze and pressure dressing. Lacerations extending into the external auditory canal required careful suturing so that healing by granulation and eventual contracture might be avoided. When the loss of tissue was so great as to preclude primary repair we felt it mandatory to cover residual cartilage.

Lips. Of the 59 injuries to the lips which required operation, 15 were defects which could not be closed, including 9 which represented loss of one or both commissures. Where tissue loss occurred, all portions of the wound adjacent to the area of loss were closed, and in the resulting defect mucous membrane was sutured to skin.

Nose. Seventy-seven patients with injury to the soft tissues of the nose were treated. Fourteen of these represented a degree of tissue loss which precluded primary suture. Those injuries which extended through the full thickness of the ala were closed in two layers, due care being used in the approximation of the borders.

Tongue and floor of the mouth. We operated on 43 injuries of the tongue. Nineteen of these involved the floor of the mouth. In treating wounds of this area meticulous débridement and total hemostasis were accomplished. Mucous membrane in the floor of the mouth was carefully closed to prevent contracture. The tongue was closed in layers to obviate all dead space. Wherever there was loss of tongue tissue, débridement and closure were carried out in such a manner that one half of the tongue was not appreciably longer than the other.

Accessory paranasal sinuses. Surgical treatment was given to 171 patients with injury to one or more of the paranasal sinuses. In many instances roentgenological examination revealed the presence of a foreign body in the sinus. This we endeavored to remove whenever possible, believing that its continued presence must certainly result in infection.

We treated 115 injuries to one or both of the maxillary sinuses. In each instance nasal antrotomy was done and vaseline gauze drain installed through the antrotomy opening. It was also necessary to do a Caldwell-Luc operation on 11 of these patients in order to remove foreign bodies.

The anterior wall of the frontal sinus was involved in 16 cases. Treatment consisted of débridement and closure with rubber tissue drain. An effort was always made to preserve the superciliary ridge. If the posterior wall of the frontal sinus were injured the case was referred to the neurosurgeon.

Three injuries which involved both the ethmoidal and sphenoidal sinuses were seen. In one of these patients spinal fluid was draining from the left nares. In that instance the entrance wound was sparingly débrided, loose bone fragments were removed, and the wound of entrance carefully closed. Nasal drainage was adequate. Due to the frequency with which such injuries involve the meninges, both extensive débridement and search for a foreign body must be avoided.

FRACTURES

Nasal bones. Seventy-six fractures of the nasal bones were reduced. Since the majority of patients in this group had multiple associated injuries which received simultaneous attention, endotracheal anesthesia was preferred. Asch forceps were used to manipulate the bones into realignment. The nasal septum was straightened and an attempt was made to return it to its groove in the vomer, but because of associated fractures this last step was not possible in every instance. Dressing consisted of dental molding compound over gauze, held in position by strapping with adhesive tape. It was necessary in 5 instances to evacuate a collection of blood from the septum. This evacuation was accomplished by means of an incision extending through the mucoperiosteum parallel to the floor of the nose.

Mandible. Of the 136 fractures of the mandible treated, 20 had lost so much bone tissue that continuity of the mandible could not be re-established. It was our policy to remove all primary and secondary foreign bodies, completely detached fragments of bone, loose teeth, and roots which were in the fracture line. Due care was exercised to remove no bone with periosteal or soft tissue attachments.

We found the anatomical classification of fractures useful only occasionally, as descriptive terms are of small benefit when methods of immobilization are being considered. When teeth remained, an all important consideration was immobilization of the mandible with the teeth in normal occlusion. Our method of choice was to attach the adapted half-round nickel silver labial arch bar to each arch separately with No. 18 gauge stainless steel wire, and subsequently to establish elastic intermaxillary traction. The latter was delayed until the postoperative period of nausea was passed.

Fractures associated with bone and tissue loss were supported in the same manner if sufficient teeth remained on both sides to give

TABLE III.—INJURIES OF BONES OF FACE

	Cases	Total
Mandible		
Fracture of body		
Unilateral	33	
Bilateral	11	44
(11 with severe loss of bone)		
Fracture of symphysis	30	39
(9 with severe loss of bone)		
Fracture of ramus	30	30
Fracture of condyle	12	12
(3 involved temperomandibular joint)		
Alveolar fracture alone	11	11
Total		136
Maxilla		
Alveolar fracture alone		37
(19 had extensive loss of teeth)		
Unilateral fractures		38
(8 had extensive loss of bone)		
Bilateral horizontal fractures		19
(5 had extensive loss of bone)		
Total		94
Zygoma		93
(19 with loss of bone)		
Nasal		76
(27 with loss of bone)		
Multiple associated fractures		128

adequate stability to the arch and still maintain the proper occlusal relation of the teeth, as well as the proper spacing of the bone fragments. The maintenance of such relationship and spacing we considered of paramount importance, for failure in these respects would unnecessarily complicate reconstructive work at a later date. We found it possible to stabilize adequately even multiple comminuted fractures of the mandible by means of the arch bar and intermaxillary traction, provided a sufficient number of teeth remained.

The edentulous mouth presented a more serious problem. There the fracture was supported by circumferential wiring. This was accomplished by selecting the proper fitting dental tray, adapting softened dental compound to the repositioned mandible, and wiring around the tray in three or more places so that the lower jaw might be firmly secured and immobilized. Again No. 18 gauge stainless steel wire was the ligature of choice.

Only once, and then with an avulsion complete except for the left condyle and ramus, did we find it necessary to use extraoral fixation on the mandible. In that instance we stabilized with fixation from skullcap to angle and lower border of ramus, with the hope of maintaining a functional left temperomandibular joint for future grafting and prosthesis.

Associated simple fractures of the alveolar process were invariably accompanied by loss of teeth. If the roots were not involved we attempted reduction and splinting, again securing stabilization by fixation to the remaining teeth with the half-round arch bar and stainless steel ligatures.

Dependent drainage was established by rubber tissue drain in all compound comminuted fractures of the mandible.

Maxilla. Ninety-four fractures of the maxilla were treated. In this series multiple associated fractures of the different bones of the face were common. In 13 cases the injuries were such as to cause extensive loss of bone.

Fixation, the type chosen depending upon the nature of the fracture, was of utmost importance both for control of hemorrhage and for maintenance of an adequate airway.

Fractures of the alveolar process alone were treated the same as were those of the mandible. Often we found that the unilateral-horizontal fracture could be maintained in place by the use of an arch bar attached to the adjacent normal maxilla and firmly ligated.

The bilateral-horizontal fracture of the maxilla presented the most difficult problem because of the downward and backward or the downward and forward displacement. Here again we attached the labial arch bar to the teeth in the maxilla, applied the plaster skullcap, and supported the floating segment of the maxilla with stainless steel wire passed through the soft tissues, over the zygoma, and attached to the arch bar in either of two locations: in downward and forward displacement the area of the first bicuspid was that of choice; in the backward displacement the area of the first molar was preferred.

When lacerations of the commissures of the mouth were present we avoided use of the Kingsley splint and similar appliances, as such devices tended to separate the wound edges and to cause a breakdown of our primary closure.

If both maxilla and mandible were fractured we did not hesitate to use elastic traction along with fixation to a plaster cap. This procedure eliminated the ineffective Barton's bandage, which we felt had no place in plastic maxillofacial surgery in an evacuation hospital.

Zygomatic malar. Fracture of the zygomatic malar was recorded in 93 patients, 19 with severe loss of bone. These fractures were usually associated with other fractures of the facial bones and, except in those cases in which the zygomatic bone alone was injured, the maxillary sinus was also involved. Entrance or exit wounds were invariably adequate for the employment of elevators. These, in conjunction with suitable tenaculum forceps for grasping the bone, were the mechanical aids necessary for reduction. After reduction was accomplished, in many instances accurate apposition and suture of soft tissues furnished adequate stabilization. Packing of the maxillary sinus with vaseline gauze through an antrotomy wound also gave support. In a few cases direct wiring or external traction with a skullcap was necessary.

Mastoid. We operated on 14 patients with compound fracture of the mastoid process. Operation consisted of débridement and removal of the air cells, introduction of sulfanilamide and penicillin powders, closure of the wound, and installation of a vaseline gauze drain.

Multiple associated fractures. One hundred and twenty-eight multiple associated facial fractures were recorded. These included fractures of the palate, ethmoid, vomer, turbinate, and lacrimal bones and will not be discussed individually.

OPERATIONS ON THE NECK

It is unnecessary to comment at length on either superficial or deep wounds of the neck which did not involve vital structures; there were 251 patients in this category. Débridement of the wound, with great care to remove all foreign and devitalized material, was routine in these cases. Whenever possible before final closure of extensive wounds the patient was allowed to cough or strain in order to make certain that hemostasis was complete.

Tracheotomy. Tracheotomy was performed 37 times. All tracheotomies were done under local anesthesia.

The low collar incision was used in preference to the vertical incision described in textbooks. The ribbon muscles were divided in the midline and the third and fourth tracheal rings were identified. A vertical incision was made through those two rings, a small segment of each ring was removed, and the tracheotomy tube was inserted. Bleeding was controlled and the wound was closed with interrupted silk sutures. Requiring tracheotomy were 15 perforating wounds of the larynx, 11 perforating wounds of the pharynx, 7 avulsive wounds of the mandible with severe injury to tongue and floor of mouth, 2 perforating wounds of the trachea, and 2 perforating wounds of both trachea and esophagus.

Wounds of the larynx. Seventeen patients with perforating wounds of the larynx, resulting from penetrating or perforating wounds of the neck, were cared for by our team. Of this series, 15 were operated on. The 2 patients on whom we did not operate require some explanation. One, a German civilian, had received a perforating wound resulting in the loss of the anterior portion of the thyroid cartilage. Through this wound a tracheotomy tube had been inserted at a field hospital. On admission to our installation the patient had pneumonia with a temperature of 103 degrees F. He died 36 hours later. The second patient, an American soldier who was admitted to the hospital with marked emphysema over neck and chest and in a state of severe shock, died a few hours after admission.

Of the 15 operable patients, 12 had perforating wounds of the thyroid cartilage and 3 had perforations of the cricoid. They presented varying degrees of emphysema and respiratory obstruction. Tracheotomy was performed under local anesthesia in all cases. This was followed by exposure of the entrance and exit wounds of the larynx through a collar incision at the level of the wound of entrance. The wound was débrided and hemorrhage was controlled; fragments of the cartilage were repositioned and held in place

by careful suture of the surrounding tissue. The wound was then repaired by primary suture.

Pharynx. Twenty patients with perforations of the pharynx were treated. These wounds were carefully débrided and closed in layers. Since we were very anxious to obtain primary healing of the mucous membrane, a soft rubber tissue drain was placed through the side of the neck only up to the suture line in the mucous membrane. The drain was removed on the second postoperative day. In several instances the entrance or exit wound was posterior to the sternocleidomastoid muscle. These injuries were handled in the same manner, except that the drain was placed in the posterior pharyngeal or lateral space and the wound was closed. All wounds in this series healed by primary intention.

ESOPHAGUS

Four perforating wounds of the cervical esophagus were seen and may be classified as follows:

1. Anteroposterior wound of the neck, perforating larynx and esophagus (Case 1).
2. Anteroposterior wound penetrating trachea and esophagus (Cases 2 and 3).
3. Transverse penetrating wound of the neck (Case 4).

CASE 1. The missile perforated the larynx at the level of the middle cricothyroid ligament, thence through the esophagus, coming to rest in the muscles of the posterior neck.

Tracheotomy was done under local anesthesia. The patient was then given a general anesthetic consisting of pentothal sodium with nitrous oxide and oxygen. The neck was opened with an incision extending from the wound of entrance to the tip of the left mastoid process; this was connected with a vertical incision along the anterior border of the sternocleidomastoid muscle, permitting the development of anterior and posterior flaps. The sternocleidomastoid muscle was divided transversely. The left superior thyroid vessels were identified and divided, permitting the left lobe of the thyroid to be retracted downward and mesially. The cervical portion of the esophagus was mobilized and the entrance and exit wounds were closed by pursestring sutures of silk, reinforced by mattress sutures. A Penrose drain was inserted into the posterior esophageal space and the wound closed. The laryngeal wound was closed by suturing adjacent tissue over it. Foreign body was not removed.

This patient was given nothing by mouth for the first 72 hours. During that time fluid and protein balance and sulfanilamide level were maintained by intravenous injections. After 72 hours the patient was given liquids, and starting on the fifth day he was given a soft diet. The Penrose drain was removed at the end of the first 48 hours; tracheotomy tube and suture were removed at the end of the fifth postoperative day. Primary healing of the wound had resulted. The patient was permitted out of bed on the seventh postoperative day and was evacuated the following day.

CASE 2. This patient presented an anteroposterior wound perforating both the trachea and the esophagus. He was treated in exactly the manner described in Case 1, and made an uneventful recovery.

CASE 3. This man also had an anteroposterior wound which perforated both trachea and esophagus. He died from anoxia resulting from a large blood clot which formed a complete bronchial cast. Had tracheotomy been performed and suction instituted earlier in the chain of evacuation, we believe this patient would have had a better opportunity to live.

CASE 4. A German civilian who was transferred to our hospital after operation in another installation had a transverse wound of the neck which perforated the cervical esophagus. The portal of entry was in the left inferior posterior triangle of the neck; the exit was through the right sternocleidomastoid muscle corresponding to the lower border of the thyroid cartilage. Operation consisted of débridement and carrying the dissection of the exit wound to the posterior esophageal space, leaving the latter open with a light packing to produce an esophageal fistula. Cervical cellulitis and mediastinitis had developed, accompanied by an elevation of temperature ranging from 101 to 104 degrees F. Sulfanilamide and penicillin therapy was instituted, together with supportive treatment with blood and plasma. It was possible to pass a Levin tube for feeding. This patient was evacuated to a civilian hospital, so no follow-up was possible.

In all 4 instances of wounds of the esophagus one symptom was outstanding—painful deglutition. This symptom was far more severe in wounds of the esophagus than in wounds of either the larynx or the pharynx. The presence of such a symptom, together with consideration of the course of the missile, determined the diagnosis.

VASCULAR INJURIES

External carotid. Patients who required ligation of one of the external carotid arteries were those who had received either avulsive wounds of the mandible or serious injuries in

the region of the temperomandibular joint, with division of the internal maxillary artery.

Early in the campaign a patient was brought in 1 hour after being hit by an 80 millimeter shell which produced a severe avulsion of the mandible. Hemorrhage was so severe that tracheotomy had to be performed with patient in the prone position. When we turned the patient over, the amount of macerated tissue made it impossible to determine which side was primarily responsible for the bleeding.

Under local anesthesia the right external carotid artery was exposed and compressed. This failed to control hemorrhage. The left external carotid artery was then exposed and observed to be much smaller in caliber than the right. When the smaller vessel was ligated hemorrhage was promptly controlled. This experience led us to believe that serious injury to one of two terminal branches of the external carotid produces vasospasm of the artery. Recognition of the vessel in spasm may be a useful diagnostic aid in deciding whether the right or the left external carotid artery is accountable for the major portion of the hemorrhage in avulsive injuries of the face.

Lingual artery. Frequently we were able to control hemorrhage from the tongue by suture ligature in the tongue itself. However, we found such treatment ineffective in 5 instances. Those patients required exposure and ligation of the lingual artery in the submaxillary space.

Internal jugular vein. Three patients with division of the internal jugular vein were seen. Whenever the path of a missile suggested injury to the contents of the carotid sheath and a hematoma of the neck was observed, a planned operation was instituted, with adequate exposure of the sheath above and below the injury. Then when the clot was dislodged, accidentally or intentionally, the resultant hemorrhage could be quickly controlled.

Common carotid artery. Two patients with injury to the left common carotid artery were admitted. The first was seen 18 hours after injury. At this time hemiplegia already existed, with marked restlessness, confusion, irritability, and total lack of co-operation. Proximal and distal ends of the vessel were ligated. The patient died on the third postoperative day.

The second patient was admitted 16 hours after injury, and, as with the first patient, hemiplegia had already developed. This patient was not operated on. He died the second day after admission.

ANESTHESIA

Anesthesia for the seriously wounded maxillofacial case is not always ideal in an evacuation hospital, due to sudden waves of patients with resultant shortage of anesthetists and anesthetic equipment. Discussion among surgeon, oral surgeon, and anesthetist almost always leads to the choice of an anesthetic that is satisfactory to all. Two factors make this anesthetic problem different from that in surgery of the trunk or the extremities. First, it may be difficult, if not impossible, to maintain an adequate airway before, during, and after operation. Second, the anesthetist and his paraphenalia must not interfere with the surgeon. In our experience, frequently the former and sometimes both factors necessitated tracheotomy before a general anesthetic was begun; and it was soon determined that the extensively or seriously wounded patient could best be cared for under general anesthesia.

Every patient who received ether was inducted rapidly to avoid the vomiting, straining, and struggling which would almost certainly result in active bleeding. Even so, suction had to be used in most cases, either during induction or just before insertion of the endotracheal tube.

The endotracheal route was generally used in the administration of ether, but whether nasal or oral depended on the nature of the injuries and on the procedure contemplated. For example, a patient requiring the placing of labial arch bars and other intraoral procedures was handled with the nasal tube. The largest possible tube (up to and including size No. 38 F.) was used to facilitate the passage of a large urethral catheter so that aspiration of the trachea might be accomplished through the same channel. This latter procedure was necessary because many patients had aspirated a large amount of blood and secretion by the time they had been transported from the battlefield and anesthetized. We believe that

TABLE IV.—ANESTHETICS

	Cases	Total
Gas-oxygen-ether		
Endotracheal	18	57
Ether		
Open drop	13	
Endotracheal (Flagg)	277	
Tracheotomy (open drop)	26	316
Sodium pentothal		391
Sodium pentothal and nitrous oxide		5
Sodium pentothal and nitrous oxide with tracheotomy		5
Cocaine, topical		2
Local infiltration and block		293
None		79
		1148

routine aspiration was in part responsible for the total absence of postoperative pneumonia in the reported series of cases. Neither were there any demonstrated cases of atelectasis, and only once was it necessary to use the bronchoscope before a patient left the operating table.

To introduce the endotrachial tube a laryngoscope with a flat blade was preferred because the tongue was displaced less by it than by the large half-round type. The laryngoscope was useful not only in passing the tube under direct vision but also in clearing the pharynx of blood, secretion, and the bits of fractured bone or teeth which were often found there. Immediately after the tube was passed, it was connected to the ether can, which will be described later. Then the pharynx was again carefully cleansed under direct vision, and 2 to 4 feet of gauze moistened in warm water or saline solution was lightly packed about the tube, to prevent aspiration of blood and secretion. Neither mineral oil nor vaseline was used because the surgeons objected to the mess of the oil on their hands and instruments. Seventy-five consecutive cases were closely followed postoperatively; no serious pharyngitis or hoarseness was noted.

A modified Flagg can was always used for the administration of endotracheal ether. This simple apparatus consisted of a bent metal adapter to which was attached a thick walled rubber tube, ½ inch inside diameter and 5 to 10 inches long, which led into the ether can. The tube should not be longer than 12 inches at the most, to avoid a large dead air space and its attendant accumulation of carbon dioxide. The "ether can" was a 14 ounce evaporated milk can with two 5/8 inch holes in the top. The inspired air was drawn over the ¼ to ½ inch of ether in the can and thence through the tube and into the lungs. This sufficed to keep the patient in light surgical anesthesia. If the plane of anesthesia became too light its depth could be increased simply by lowering the tube further in the can, or even by warming and gently agitating the can with the hand. Oxygen was administered, when needed, through a catheter inserted in the open hole of the can.

This method of administering ether was greatly favored by our team. The apparatus was easy to clean, could be covered by drapes, and was almost completely automatic: as the patient became more deeply anesthetized his respiration became more shallow and less ether was vaporized. The hazard of explosion was controlled by having the maxillofacial table situated at the end of the operating tent away from central supply and from stoves, when they were used.

Gas-oxygen-ether could have been used more frequently, but since 8 to 10 operating tables were being used simultaneously, it was felt that the two gas machines could best be used for the abdominal and chest cases. Approximately 50 per cent of the ether patients were inducted with gas-oxygen-ether and then intubated. The tube was then connected to the Flagg can, freeing the gas machine for other uses.

Though it was a rule that no patient whose wounds communicated with any of the air passages, including the paranasal sinuses, should receive pentothal, Table IV reveals a relatively high number of pentothal anesthetics administered. This was possible only because approximately one-half of the wounds in this series did not communicate with air passages.

Intubation under pentothal anesthesia was accomplished in some instances, but the tendency to severe laryngospasm and coughing made such procedure unpopular. Ethel chloride and drop ether, used for induction in about 25 per cent of the patients, were especially reserved for those who had extensive wounds of the mouth, to get them through the

excitement stage quickly and quietly. Patients were merely brought to a state of unconsciousness with ethyl chloride spray; then a fresh mask was applied and the administration of drop ether was begun. One death can probably be attributed to ethyl chloride induction.

Sodium pentothal was frequently used for patients requiring operation on the posterior neck. In such instances it was most convenient, from the anesthetist's point of view, to use the neurosurgeon's occipital headrest. Not only was the airway then easy to maintain but the surgeon also welcomed the resultant stability and adjustability of the patient, who could be settled in a comfortable position while still awake.

Seventy-nine patients received no anesthetic. Nearly all of that group had burns of the hands and face requiring a minimum of painful manipulation. All had received a preoperative injection of ¼ to ½ grain of morphine.

POSTOPERATIVE CARE

Postoperative treatment of plastic maxillofacial injuries was guided in part by the length of time the patient was to remain in our installation. The hospital operated under directives declaring chest and abdominal injuries nontransportable for 7 and 10 days, respectively; therefore retention of the severely injured plastic maxillofacial patients did not at any time interfere with its mobility. Since all the latter type patients were operated upon under a general anesthetic which was administered through either an endotracheal catheter or a previously placed tracheotomy tube, scrupulous attention to their postoperative care was required.

Early postoperative care. During the anesthetic and opiate recovery period it was essential to maintain a dry airway, to correct dehydration and shock, and to continue chemotherapy.

It was not necessary to remove the endotracheal catheter immediately after surgery, and leaving it *in situ* conferred two advantages: (1) it facilitated the maintenance of a patent and dry airway, as did use of a tracheotomy tube, and (2) it expedited the administration of oxygen whenever that procedure was necessary.

Immediately available suction for each patient was imperative. The length of the period during which this procedure was required depended in great part on the amount of material aspirated and on the state of shock. Electrically operated mechanical suction was most desirable, but there was not a sufficient number of such units in the hospital. Consequently, that equipment had to be supplemented by foot pedal apparatus, exhaust suction from gasoline motors, water suction, or a simple syringe suction. Only by utilizing one or more of these supplementary means was adequate suction available in postoperative and shock wards.

The parenteral use of crystalloid solutions for the correction of dehydration and the further use of blood and plasma in the treatment of shock were necessary. When blood was used in a preservative solution containing chloride, care was exercised in the further administration of saline solutions so that water retention might be prevented. We found it better to use 5 per cent glucose in distilled water, rather than saline, under those circumstances.

Chemotherapy consisted of penicillin, 20,000 Oxford units every 2 hours by intramuscular injection, and sulfadiazine, 1 gram every 4 hours by mouth. This was routine, unless special circumstances required other means of administration or different dosage. Sodium sulfathiazole in solution was given intravenously to patients unable to take sulfadiazine by mouth.

Late postoperative care. Following the anesthetic and opiate recovery phase, the patients were set upright to facilitate venous drainage and to reduce edema, thus preventing tension on sutures and local anoxia of the involved tissues.

For those patients who had injuries of the oral or pharyngeal cavities, feeding was begun at once by oral or nasal catheter, depending on the nature of the injury. By this means those patients were immediately on a liquid diet containing 2500 to 3000 calories. The No. 18 F. urethral catheter with 50 cubic centimeter syringe was excellent for this purpose. The catheter was removed after each feeding. After two or three lessons the patient could

feed himself. This method not only insured adequate food and fluid intake, but also improved the wound hygiene.

Meticulous hygiene of the cavities was then instituted. This consisted of irrigation with physiological saline solution followed by hydrogen peroxide or potassium permanganate solution. Sinuses or bones exposed by extensive loss of tissue were sprayed with activated zinc peroxide solution. Here again, after two or three lessons, the patient welcomed the opportunity of caring for himself.

When adequate early surgical treatment was carried out it was seldom necessary to allow the tracheotomy tube to remain in place for more than 4 days. Throughout the period covered by this report a high percentage of tracheotomy tubes were removed before the patient was evacuated, and during the last 5 months all tubes were removed before that time. In no case did follow-up records reveal any ill effects. We believe that there is a tendency to allow the tube to remain in place longer than its period of usefulness, thereby prolonging the time required for closure and increasing the amount of scar tissue.

BURNS

Practically all burns seen at this evacuation hospital were second or third degree burns. In approximately 70 per cent of the cases morphine was sufficient for débridement and dressing. The remaining 30 per cent had additional injuries requiring administration of a general anesthetic. Petrol and flash burns of the extremities were treated, following débridement, with the application of fine mesh vaseline gauze, pressure dressing, and immobilization.

Due to gross contamination by excretions from nose and mouth, dressings were not used on the face, except for evacuations. When patients arrived at the ward they were placed in Fowler's position on a sterile sheet with a sterile towel for pillow cover. As a result of maintaining this position less edema developed.

All phosphorus burns admitted to the hospital had received previous application of copper sulfate. Even so, the more deeply imbedded particles required excision, but if this were unnecessary the burns were treated as petrol or flash burns.

Three civilian children with third degree burns of face and hands were treated with excision, full thickness skin graft to the face, and split thickness grafts to cover the hands. This treatment was adopted because both evacuation to civilian hospitals and later care were very uncertain.

Postoperative treatment of burns entailed (1) administration of blood and blood plasma for hemoconcentration, (2)chemotherapy, and (3) the maintenance of adequate fluid intake.

DEATHS AND THEIR CAUSES

CASE 1. Clinical diagnosis: perforating wound of face, resulting in compound comminuted fracture of the mandible, bilateral horizontal compound comminuted fracture of the maxilla, and extensive laterations of the face. Cause of death: irreversible shock.

CASE 2. Clinical diagnosis: perforating wound of neck, with perforation of larynx. No operation performed. Cause of death: emphysema with cellulitis.

CASE 3. Clinical diagnosis: perforating wound of the face: portal of entry was in the region of the left temperomandibular joint, and exit was through floor of the mouth. No operation performed. Cause of death: hemorrhage from internal maxillary artery.

CASE 4. Clinical diagnosis: multiple perforating wounds, with third degree burns of both legs. Cause of death: irreversible shock.

CASE 5. Clinical diagnosis: perforating wound of trachea. No operation performed. Cause of death: hemorrhage producing clot which completely filled the tracheobronchial tree.

CASE 6. Clinical diagnosis: perforating wound of neck. No operation performed. Cause of death: induction of anesthesia with ethyl chloride.

CASE 7. Clinical diagnosis: perforating wound of larynx. Not operated on. Cause of death: pneumonia.

CASE 8. Clinical diagnosis: second and third degree burns involving 80 per cent of the body surface. Cause of death: irreversible shock.

CASE 9. Clinical diagnosis: second and third degree burns of 100 per cent of the body surface. Cause of death: irreversible shock.

CASE 10. Clinical diagnosis: perforating wound of neck with division of left common carotid artery. Cause of death: thrombosis of the vessel from the site of injury to the circle of Willis, and with hemiplegia.

CASE 11. Clinical diagnosis: perforating wound of the neck with division of the left common carotid artery. Cause of death: thrombosis of the vessel from the site of injury to the circle of Willis, and with hemiplegia.

SUMMARY AND CONCLUSIONS

1. Two cases with successful primary closure of the cervical esophagus are reported.

2. Endotracheal anesthesia is preferred in the severely injured maxillofacial patient.

3. Low collar incision is preferred for the tracheotomy. Tracheotomy tubes often remain *in situ* longer than their period of usefulness.

4. Vasospasm of the external carotid artery can be used as a diagnostic sign in determining whether the right or the left external carotid artery is responsible for the major portion of the hemorrhage in avulsive types of injury to the face.

5. Primary closure of neck and face wounds is the treatment of choice.

TRANSVERSE PRESENTATION

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A REVIEW of early obstetrical literature reveals that abnormal presentations usually ended with destruction of the fetus. But as obstetrics emerged as an art, with its goal a healthy mother and infant, instruments and methods were devised to cope with the problem of transverse presentation. Internal version, external version, forceps, and cesarean section have reduced the number of unfavorable results. The accumulation and the intelligent interpretation of statistical data have further reduced mortality.

Stephenson reviewed the original paper of Sir Thomas Denman (1785) who superficially described the mechanism involved in 3 cases of neglected transverse presentation in which spontaneous delivery eventually occurred. He ascribed the term spontaneous evolution to this rare outcome. Stephenson also reviewed the original paper of Douglas (1819) who made a more searching inquiry of the phenomenon. Roederer (1756) described partus conduplicato corpore, or birth with the doubled body. Eastman again reviewed the subject in 1933. In modern obstetrics this form of delivery is of historical interest and is only rarely seen in the neglected case. Modern teaching insists upon some form of interference when a patient is encountered with a persistent transverse presentation. The physician who pursues a course of watchful waiting in these difficult cases invariably finds himself driven to desperate and heroic therapy, often resulting in death of the infant and/or the mother.

In the late 1800's an abundance of German literature appeared concerning the treatment of transverse presentation by internal podalic version. Most authors accepted internal podalic version as the treatment of choice, and were chiefly concerned with the state of the cervix at the time such interference was justified. Sachs and Poeck later (1926) summarized the opinions of leading German obstetricians about half of whom felt that internal version should be performed prior to full dilatation, and the other half believed that internal version was not indicated until full dilatation of the cervix had occurred. Cesarean section was not entirely forgotten, but it was thought that the operation was not indicated unless additional factors were present. Kamniker stated that the mother should realize the added risk, and her wishes should be considered. Chatunzew was of the opinion that cesarean section was indicated in cases in which the membranes ruptured early and that both fetal and maternal mortality should be reduced by such treatment. In the more recent American literature series of cases have been reported by Eastman, Novey and Schneider, and Torpin. Eastman's series covered the period from 1896 to 1931, and Novey and Schneider's series the period from 1920 to 1939. It is the purpose of this paper to present a more recent series of cases, and if possible, to evaluate the influence of advances in surgery, chemotherapy and the development of

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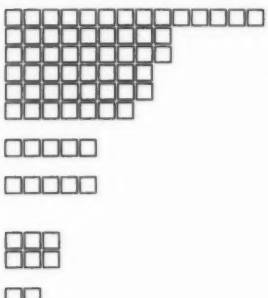
blood banks, which appear to be influencing the method of treatment in cases of transverse presentation.

In a review of the records of 45,000 deliveries at The Woman's Clinic of The New York Hospital between 1932 and 1946, 78 cases of transverse presentation are recorded. Arbitrarily, all cases of twin deliveries in which the second twin was transverse have been eliminated since in this instance the problem is not the same. Cases in which the original presentation was transverse and spontaneous version occurred have also been eliminated because many such cases were not reported and one could not be certain of the validity of the findings. It was also necessary to eliminate cases in which the fetus weighed under 1500 grams, for here again many were not reported and they apparently offered no special problem. However, it was just as necessary to include the group in which the fetus weighed between 1500 to 2000 grams as will be pointed out later. The authors fully realize that cases in this group went unrecognized or were not reported, and the incidence of transverse presentation in which the fetus is between 1500 to 2000 grams must be greater than indicated in their series. No attempt has been made to differentiate between the so-called oblique presentation and transverse presentation. The broad definition of transverse presentation—where the long axis of the fetus crosses the long axis of the mother—has been used throughout the study (Chart 1).



		Per cent
14	Unknown	17.9
9	Multiparity	11.5
9	Myoma	11.5
8	Placenta previa	10
8	Prematurity	10
7	Uterine abnormality	9
5	Contracted pelvis	6.4
5	Premature ruptured membranes	6.4
3	Ventral hernia	3.8
3	Previous uterine suspension	3.8
2	Hydramnios	2.6
2	Insertion of bag	2.6
2	Excessive size infant	2.6
1	Pelvic kidney	1.3

Chart 1. Etiological factors in 78 cases of transverse presentation.

The importance of the etiological factor lies in its influence on the plan of treatment of each individual case. As in other series of cases it was difficult in a large number of instances to determine the reason for the abnormal fetal presentation. In general, the findings are much the same as those of other investigators. Myoma uteri was considered the etiological factor only in those cases in which the myomas were of such size that they might presumably affect the presentation of the fetus. When there was no other obvious etiological factor, the cause was attributed to multiparity if the woman had previously given birth to two or more infants, to prematurity if the infant weighed under 2500 grams, and to excessive size infant if the infant weighed more than 4000 grams. It is evident that it would be more proper to call these the probable etiological factors. Of unusual interest is the single case of transverse presentation in which the causative factor was the presence of a kidney overlying the pelvic brim as proved at operation. This patient had had one previous pregnancy which was also complicated by a transverse presentation terminated by cesarean section.

TABLE I.—DISTRIBUTION OF 78 CASES OF TRANSVERSE PRESENTATION ACCORDING TO PARITY

Parity	No. cases	Per cent
0	17	21.8
1	26	33.3
2	20	25.6
3 or 4	9	11.5
5 or more	6	7.7
Average–1.8	Total–78	Total–99.9

A tabulation of the 78 cases of transverse presentation according to parity again emphasizes the influence of multiparity as an etiological factor (Table I).

TABLE II.—DISTRIBUTION OF 78 CASES OF TRANSVERSE PRESENTATION ACCORDING TO BIRTH WEIGHT OF THE INFANT

Infant weight in grams	No. cases	Per cent
1500–2000	2	2.6
2000–2500	14	17.9
2500–3000	13	16.7
3000–3500	25	32.1
3500–4000	17	21.8
4000–4500	7	9.0
Average–3003 grams	Total–78	Total–100.1

A distribution of the patients according to the birth weight of the infant shows the greatest number of cases of transverse presentation occurred when the infant weighed between 3000 and 3500 grams (Table II).

FETAL MORTALITY

The fetal mortality figures reported by the German authors vary widely, being from 19.0 to 47.2 per cent. This appears to be due to the fact that some authors included in their series all cases in which the fetus weighed 1000 grams or more. It is obvious that some clinics were seeing many more neglected cases of transverse presentation than others. Novey and Schneider report the fetal mortality to be 30.7 per cent in 114 full term infants at the University Hospital, Baltimore. Eastman's figure is 47.2 per cent in 93 cases at the Johns Hopkins Hospital when the fetus weighed 2500 grams or over, and 30.0 per cent when he eliminated the cases in which the fetal heart was not heard on admission to the hospital. In the present series, there were 62 cases in which the birth weight of the infant was 2500 grams or more, and 9 fetal deaths occurred (14.5%). If the 4 cases are discarded in which the fetal heart was not heard on admission to the hospital, the fetal mortality was 8.6 per cent (Table III).

TABLE III.—FETAL MORTALITY IN 62 CASES OF TRANSVERSE PRESENTATION IN WHICH THE FETUS WEIGHED 2500 GRAMS OR OVER

Classification	No. cases	No. deaths	Per cent Mortality
Total cases	62	9	14.5
Fetal heart present	58	5	8.6
Method of delivery			
Vaginal	28	5	18.0
Abdominal	30	0	0.0

In the entire series of 78 cases there were 18 fetal deaths. As will be noted from Table IV, 7 deaths occurred prior to the onset of labor, 8 were associated with labor and delivery, and 3 were neonatal deaths.

These fetal mortality figures are lower than generally reported. We believe that this fact is due to our high incidence of delivery by cesarean section which in turn has been influenced by the development of blood banks and advances in chemotherapy, particularly the introduction of the sulfonamide drugs and penicillin. There were 5 live-born infants who sustained injuries during delivery (all delivered by internal podalic version and breech extraction): 2 nerve injuries, 1 intracranial hemorrhage, 1 fractured clavicle, and 1 hematoma of the knee.

TABLE IV.—CAUSES OF 18 FETAL DEATHS OCCURRING IN 78 CASES OF TRANSVERSE PRESENTATION

	No. cases	No. deaths
Prior to labor		7
Unknown	5	
Hypertensive disease	1	
Pre-eclampsia	1	
During labor		5
Prolapse of cord	4	
Unknown	1	
During delivery		3
Difficulty with aftercoming head	2	
Prolapse of cord	1	
Neonatal death		3
Prematurity	2	
Asphyxia	1	

MATERNAL MORTALITY

In the series there occurred 1 maternal death (1.3%), which rate compares favorably with other reports. Eastman records 5 maternal deaths in his cases and makes the interesting observation that all 5 deaths occurred in immature or premature labors, the largest child weighing 2030 grams.

The patient was a 37 year old, black, septipara, tredecimgravida, with negative Wassermann, and normal pelvis. Her expected date of confinement was June 17, 1940. She was admitted to the hospital at 6:30 p.m. on June 7, 1940, because of the absence of fetal movement for 2 days and the onset of mild labor at 1 p.m. accompanied by slight vaginal spotting. On admission no fetal heart sounds could be heard and the patient had a fever of 38 degrees C. which was attributed to intrapartum infection. Abdominal examination revealed a tender uterus and the fetus in transverse presentation. A sterile vaginal examination at 8 p.m. showed the cervix to be soft and 6 centimeters dilated with the maternal surface of the placenta palpable over the entire cervical os. Brisk vaginal bleeding was present so the placenta was pierced by the examining hand, both feet grasped and pulled into the vagina. This controlled the hemorrhage. Anesthesia was discontinued and with each uterine contraction, gentle traction was made on the feet. Fifty minutes later the patient was delivered without difficulty of a 2740 gram, macerated infant. One minute later the placenta was expressed spontaneously and completely. The cervix was inspected and found to be intact. The uterus was explored and no defect noted. The uterus

TABLE V.—METHOD OF DELIVERY IN 78 CASES OF TRANSVERSE PRESENTATION

Method	No. cases	Per cent	No. deaths Maternal	Fetal
Internal podalic version	39	50.0	1	12*
Cesarean section	36	46.1	0	0
External version—spontaneous delivery	2	2.6	0	0
Spontaneous	1	1.3	0	0

*Fetal heart heard on admission to hospital

contracted well. The total blood loss was 400 cubic centimeters.

Immediately following delivery the patient received 500 cubic centimeters of whole blood intravenously and was in good condition. One and one-half hours later the blood pressure was found to be 60/20 and the patient was exhibiting the classical signs of shock. The uterus was found to be relaxed, and an additional 400 cubic centimeters of blood and clots were expressed from the uterine cavity. It was apparent that the shock was out of proportion to the blood loss, so the patient was prepared for re-examination of the uterine cavity. At 11:15 p.m. the second examination revealed a rent in the lower uterine segment on the right side and extending into the right broad ligament. The patient was prepared for further transfusions and immediate laparotomy.

A hysterectomy was performed in 42 minutes, during which time the patient received 1050 cubic centimeters of whole blood, but her condition remained critical. One hour after operation the patient had reacted and was rational and co-operative. Her general condition had improved. The blood pressure was recorded at 78/40; the pulse of fair quality but rapid. During the next hour her course was steadily downhill in spite of the transfusion of an additional 500 cubic centimeters of whole blood. She did not respond to the usual emergency drugs, and expired 7 hours after delivery (4 hours after hysterectomy).

METHOD OF DELIVERY

It will be noted in Table V that almost half of the deliveries in this series were by cesarean section. In 93 cases of transverse presentation in which the fetus weighed 2500 grams or over and the fetal heart was heard on admission to the hospital, Eastman reports 21 cesarean sections (22.6%). Novey and Schneider record 21 sections in 151 cases (13.9%). In the present series, considering only infants weighing over 2500 grams when the fetal heart was present on admission, there were 58 cases of which 30 were delivered by cesarean section (51.7%).

Table VI describes the methods of treatment and delivery in greater detail.

TABLE VI.—DETAILS OF METHOD OF DELIVERY IN 78 CASES OF TRANSVERSE PRESENTATION

No. cases	Method
36	Cesarean section
	Classical 27
	Low-flap 6
	Porro 2
	Extraperitoneal 1
28	Internal podalic version and breech extraction
5	Intrauterine bag, internal podalic version, breech extraction
3	Attempted external version, internal podalic version, breech extraction
1	Intravaginal bag, internal podalic version, destructive operation
1	Abdominal binder, internal podalic version, breech extraction
1	External version, binder, internal podalic version, destructive operation
1	External version, abdominal binder, spontaneous delivery
1	External version, manual fixation of head, spontaneous delivery
1	Spontaneous delivery

TREATMENT

In the treatment of transverse presentation no strict regimen can be outlined for all cases. To some extent the treatment of an individual case depends upon certain variable factors.

1. Etiological factor. The presence of a pelvic tumor, contracted pelvis, uterine abnormality, or placenta previa might contraindicate vaginal delivery and make cesarean section mandatory. Conversely, the presence of a premature infant might influence the attending physician to allow delivery from below. But as previously pointed out, Eastman's 5 maternal deaths occurred when the infant weighed 2030 grams or less.

2. Age and relative sterility of the patient. In the elderly primipara with a long history of relative sterility, the importance of the fetus is greater. In such a case one would be inclined to choose cesarean section as the method of delivery. Again, one would surely hesitate to perform a hysterectomy on a neglected young primipara, and would use every means to preserve the organ for future pregnancies.

3. Duration of pregnancy. If confronted with a previable infant, radical measures are to be avoided. Under certain conditions one would be more inclined toward vaginal delivery when the fetus was small, and toward cesarean section when the fetus was excessively large.

4. Condition of fetus. If the fetus is in dire straits, clinically dead, or malformed, delivery from below is usually indicated and cesarean section to be avoided.

5. Duration of labor. When abdominal delivery is decided upon, the duration of labor affects the selection of the type of cesarean section to be performed. As labor becomes protracted, thinning of the lower uterine segment makes external and internal version increasingly hazardous procedures.

6. Condition of the membranes. With rupture of the membranes and the escape of the amniotic fluid, prolapse of the cord is an ever-present and extremely unwelcome complication. External version is more difficult, often impossible, and frequently injudicious. Braxton Hicks or internal podalic version may lead to fetal death unless the patient may be immediately delivered.

Antenatal care. Novey and Schneider emphasize the importance of adequate prenatal care. During the antenatal period careful examination would reveal the presence of a pelvic tumor, contracted pelvis, uterine abnormality, hydramnios, or an excessive size infant. The attending physician would then have some insight as to the cause of a persistent transverse presentation as the patient approached term. If such conditions were overlooked their recognition might prove much more difficult at time of labor. The multipara with a pendulous abdomen or ventral hernia may obtain great relief from an abdominal support during the latter months of pregnancy, and at the same time the likelihood of transverse presentation is reduced. Although most physicians are reluctant to accept external version as a routine procedure as advocated by Ryder, its use in the last few months of pregnancy when a transverse presentation is discovered is of value. If studies during the antenatal course indicate that abdominal delivery will be necessary, the patient may be admitted to the hospital at or near term for elective cesarean section.

Precautions. It has been the policy of the Woman's Clinic of The New York Hospital to take certain precautions when a patient is admitted with the fetus in transverse presentation. Immediate blood typing and matching is performed in anticipation of a difficult delivery. If the etiological factor is unknown or obscure, a careful search is carried out to determine the presence or absence of pelvic contraction and fetal abnormalities. Soft tissue x-ray films may also be done when placenta previa or pelvic tumors are suspected. A sterile vaginal examination may be performed. Prophylactic sulfonamide drugs and/or penicillin may be administered.

Observation. At all times the patient should be under close surveillance for signs of impending uterine rupture. Auscultation of the fetal heart is carried out at frequent intervals so that the first signs of fetal embarrassment will be noted. Constant watch is kept for rupture of the membranes and the prolapse of a small part or the cord.

In discussing the treatment of transverse presentation the methods to be employed seem naturally to fall into groups which are directly dependent on the duration of labor and the condition of the membranes.

Early labor. Membranes intact. It would be interesting to know just how many times spontaneous versions occur. It is probably safe to assume that in one-half or more of cases the fetus rotates spontaneously so that either the vertex or breech presents. External version should be attempted. If it is successful, the presenting part should be fixed manually over the pelvic brim until it is secure; if unsuccessful, the patient is entitled to a short trial of closely observed labor to allow every opportunity for spontaneous version to occur. Although many advocate the use of abdominal binders to maintain the new presentation, we have found spontaneous reversion to the transverse to be common. With an abdominal binder in place auscultation of the fetal heart and abdominal palpation are difficult. Often one is lulled into a sense of false security only to find as labor progresses and the membranes rupture that the cord or a small part is present in the vagina. If absolute indications are present for cesarean section, the patient should be prepared for operation.

Early labor. Membranes ruptured. In this instance the treatment is much as outlined above, but once the membranes are ruptured external version becomes a dangerous pro-

cedure unless the cervical os is tightly closed and a sufficient quantity of amniotic fluid remains. If external version is successful, some writers advocate the use of the Willett clamp to maintain the fetal head in the pelvis. We have had no experience with this method.

Midlabor. Membranes intact. At this stage cesarean section remains feasible. As previously pointed out, hysterectomy may be performed in the multipara who is grossly infected. On the other hand, in the primipara every attempt should be made to save the uterus. Intrauterine bags are of questionable value in aiding in the further dilatation of the cervix and preventing prolapse of the cord or a small part. They may sometimes be used to control hemorrhage when placenta previa is discovered. Eastman advises the use of an intravaginal bag to exert counterpressure and so prevent rupture of the membranes. Our experience with the intravaginal bag has been limited and not satisfactory, for the bag has failed to prevent rupture of the membranes and has proved to be extremely painful.

Midlabor. Membranes ruptured. Here the treatment is much the same as outlined for midlabor and intact membranes. The intervaginal bag, however, has no use once the membranes are ruptured.

Terminal labor. Once the cervix is fully dilated or nearly so, internal podalic version and breech extraction may be carried out. The available statistics show that this method of treatment carries with it a high fetal and greater maternal mortality rate. It is one of the leading causes of uterine rupture, and, in transverse presentation this is particularly important, for the lower uterine segment is often very thin or a low implanted placenta may be present. A review of the maternal deaths reported in cases of transverse presentation always shows a large number of the deaths attributed to rupture of the uterus following internal podalic version and breech extraction, while the occasional case is due to infection or hemorrhage. At the Woman's Clinic of The New York Hospital, Pastore found the average blood loss at delivery to be 244 cubic centimeters. The 38 cases of transverse presentation delivered by internal podalic version and breech extraction had an average blood loss of 335 cubic centimeters. Six of these cases suffered a postpartum hemorrhage (15.8%). We can only counsel as do Novey and Schneider, that unless certain requirements are satisfied (particularly a sound uterus, the absence of tumors, lack of disproportion and a sufficient quantity of amniotic fluid), internal podalic version is extremely hazardous. If these requirements are not satisfied internal podalic version should not be attempted, but rather the fetus be sacrificed in a destructive operation. When the cervix is fully dilated and the fetus dead, the least traumatic procedure attended by the smallest risk is a destructive operation, particularly exenteration.

DISCUSSION

An investigation of the high fetal mortality rate associated with transverse presentation revealed that 7 deaths occurred prior to the onset of labor, 8 were associated with labor and delivery, and 3 were neonatal deaths. The 1 maternal death is recorded in detail.

The treatment of transverse presentation is discussed at some length. In order further to reduce fetal and maternal mortality, stress should be placed on good antenatal care, the observance of certain precautions in anticipation of a difficult delivery, and the intelligent evaluation of the individual case as to method of delivery. The high mortality figures that accompany delivery from below are pointed out, and the complications that arise from unwise internal podalic version and breech extraction are emphasized. The development of blood banks and the recent advances in chemotherapy should further reduce the number of deaths. The more frequent employment of cesarean section as the method of delivery in transverse presentation is indicated because of the attendant low mortality figures.

SUMMARY

1. Seventy-eight cases of persistent transverse presentation occurring in approximately 45,000 deliveries at the Woman's Clinic of The New York Hospital are reported. A brief account is given of the probable etiological factors, and a tabulation of the cases according to parity again emphasizes the importance of multiparity.

2. One maternal (1.3%) and 18 fetal (23.1%) deaths are recorded. In 58 cases in which the fetal heart was audible on admission to the hospital and the infant weighed 2500 grams or over, 5 fetal deaths occurred (8.6%).

3. This series differs from others in that in 46.1 per cent of the cases delivery was by cesarean section, and in this group there were no fetal or maternal deaths.

NOTE.—Since this study was completed, in 5 further cases of transverse presentation delivery was by cesarean section without fatality.

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GASTRIC CANCER: LAPAROTOMY, RESECTABILITY, AND MORTALITY

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THE purpose of this paper is to analyze the present status of the surgical treatment of gastric cancer with respect primarily to exploratory laparotomy, resectability, and postoperative mortality.

The only effective treatment of gastric cancer at present is surgical resection. The progress made in the perfection of this procedure is indicated by the increasing number of patients submitted to operation, the lowered mortality rates, and the longer periods of postoperative survival. However, the published statistics are quite variable and evidence different concepts of operability and resectability as well as different mortality and survival rates.

From the Charity Hospital in New Orleans, Morris reports 1,163 patients with gastric cancer, admitted between 1932 and 1940, of which 829 were considered inoperable; 344 were subjected to operation with 138 hospital deaths. In a special group of 200 patients subjected to operation, the same author reports 55 gastrectomies with a mortality of 56 per cent. In 1931, the mortality of gastric resection at that institution was 51.4 per cent while in 1942, it was 16 per cent.

From Seattle (13) are reported 273 gastric cancers with only 12 resections and 6 survivors. Emmet describes 74 cases with 24 gastrectomies and a mortality of 20 per cent. At the Cincinnati General Hospital (22), between 1932 and 1936, 42 per cent of the patients with gastric cancer underwent operation with a resection rate of 9 per cent; by 1939, the resection rate had risen to 43 per cent. Thorstadt reports 454 patients from Harper Hospital with 57.7 per cent operability, 19.4 per cent resectability and a gastrectomy mortality of 64.7 per cent while at Receiving Hospital, a municipal institution, he found 23.4 per cent of 516 patients operable and 9.8 per cent resectable with a gastrectomy mortality of 57 per cent. This percentage suggests that operability and resectability decreased as the economic level was lowered. Livingston and Pack quote Sandweiss (12, p. 15) to the effect that 7.7 per cent of the patients with gastric cancer in Detroit received resection and 3 per cent reached the stage of resection survival. In an extensive survey, Baron found 25 per cent of explored patients resectable with a 30 per cent resection mortality (3).

Table I shows that the operability of gastric cancer varies from less than 25 per cent at some institutions to more than 89 per cent at others while resection mortalities range from 4.9 per cent to 64 per cent. In order to avoid confusion these statistics must be carefully analyzed and interpreted particularly with respect to the following 4 factors: (1) the total number of patients with gastric cancer, (2) the number subjected to exploration, (3) the number in which resection of the primary growth is accomplished, and (4) the number of survivors in relation to the total.

ANALYSIS OF CASE DISPOSAL

At the University of Chicago over a 17 year period (1927 to 1944) some 576 patients with gastric carcinoma were examined. In a study of the disposition of the unselected total it was noted that laparotomy was advised in 71.8 per cent, not advised in 13.3 per cent and refused in 4.3 per cent. Of the group 67.5 per cent accepted exploration, 35.3 per cent underwent resection, and 26.05 per cent survived resection. A detailed examination of the case disposal, however, reveals that 85, or 14.7 per cent, of the 576 did not return for definitive advice or were admitted for special procedures such as gastroscopy. Of the 491 who did return for advice, laparotomy was not advised in 77 (16.5 per cent) refused in 25 (5.1 per

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TABLE I.—COMPARATIVE STATISTICS CONCERNING LAPAROTOMY, RESECTABILITY, AND MORTALITY

Reference	Author	Period surveyed	Patients in series No.	Laparotomy Per cent	Resectability of total Per cent	Resection Mortality	
						Simple Per cent	Complicated or radical Per cent
12	Peck		527	77.4	14.8	28	
10	Joll	1920–1940	*	‡368	‡123	19	
19	Thorstadt (Receiving Hospital)	1928–1942	516	23.4	9.8	57	
19	Thorstadt (Harper Hospital)	1928–1942	454	57.7	19.4	64.7	
11	Lahey	To 1940	311	69.1	44.6	*	
6	Counsellor, Waugh, Clagett	1943	538 Approximate	60	35	4.9	29.4
20	Walters, Gray and Priestly	1907–1938	10,890	57.3	25.5	16.2	
4	Bocharov	1928–1938	1,020	89.8	34.2	32.4	
8	Engels		*	42	17	5	25
	University of Chicago	1928–1943	300	83.5	43.5	20.8	51.4
18	St. John, Swenson, Harvey	1938–1942	244	*	36.5	17.9	
16	Hansen (Denmark)	1930–1940	1,547	*	19.7	41.5	
16	Weese (Tubingen)		883		35 Approximate	17.3	41
16	Finsterer		*	*	*	6.1	39
16	Kiel Clinic		*	*	*	*	44
3	Baron (Spain)		440	44	20.4	38	80
17	P rat (Uruguay)		130	25	11	50	

*Not stated ‡Cases

cent), and performed in 389 (78.4 per cent). Thus 466 patients, 80.9 per cent of the total group of 576, accepted the physician's advice and form the basis of a more accurate evaluation as to surgical intervention.

LAPAROTOMY AND RESECTABILITY

Of the 466 patients who followed the advice given laparotomy was carried out in 389 or 83.5 per cent; the remaining 16.5 per cent were considered inoperable. Metastases to the liver or to distant organs and carcinomatous involvement of the peritoneum constituted the major contraindications to operation. Exploration alone was carried out in 20.1 per cent while palliative procedures consisting of gastrostomy, gastroenterostomy and jejunostomy were performed in 19.7 per cent. Resection was possible (Table II) in 203 cases, 43.5 per cent. Partial resection was the most widely employed operation, 36 per cent (of 466) being subjected to this procedure. Total gastrectomy (transabdominal 3.5 per cent and transthoracic combined with partial esophagectomy 4.2 per cent) formed a relatively small part of the effective surgical measures. The resection rate of 43.5 per cent is high and indicates that the procedure was undertaken in a number of patients who presented far more than the average risk. Approximately 25 per cent of the partial resections were complicated by metastatic involvement of neighboring organs. Partial resection of the liver, pancreas, colon, removal of the spleen, and extensive lymph node dissections were often performed. Of the total patients undergoing partial resection, 79.2 per cent survived and were discharged from the hospital; approximately half of the patients undergoing transthoracic and transabdominal total gastrectomy were discharged, the mortality in 35 patients subjected to these procedures being 51.4 per cent. A total of 150 patients survived gastrectomy of all types. Figured on the basis of the 466 patients who sought advice, these 150 represent 32.2 per cent; when figured on the basis of the 389 subjected to exploration they constitute 38.8 per cent.

TABLE II.—OPERATIVE PROCEDURE AND MORTALITY (466 CASES)

Procedure		Number of patients	Per cent of total	Operative mortality Per cent	Operative survival Per cent
Laparotomy not advised		77	16.5		
Resections	Partial	168	36	20.8	79.2
	Transabdominal total gastrectomy	16	3.5	43.7	56.3
	Transthoracic gastrectomy and partial esophagectomy	19	4.2	57.8	42.4
	All types	203	43.5	26.1	73.9
Palliation	Jejunostomy, Gastroenterostomy, Gastrostomy	92	19.7	26	64
Exploration		94	20.1	13.6	86.4
Total operations		389	83.5	23.3	76.7

POSTOPERATIVE MORTALITY

The mortality in the 389 operations was 23.3 per cent, 91 deaths (Table II). In the 203 resections of all types there were 53 deaths, a mortality of 26.1 per cent. In the 168 partial resections there were 35 deaths, 20.8 per cent. Examination of reported rates in the literature seems to reveal a downward trend in the reported rates of resection deaths in experienced hands, although the indications for operation and for resection have varied so greatly that one cannot be certain of this. In the present series, from 1929 to 1940, there were 119 partial resections with a mortality of 22.6 per cent with an operative survival of 77.4 per cent while from 1940 to 1944 there were 49 partial resections, with a mortality of 16.3 per cent with an operative survival of 83.6 per cent. Finsterer reports a mortality of 6 per cent for uncomplicated resection and of 30 per cent for complicated partial resection. Weese found a 17.3 per cent mortality for simple resection and 41 per cent for complicated resections. These figures are somewhat difficult to interpret for the terms "uncomplicated" and "complicated resection" may be defined somewhat differently. Brunschwig has advanced the thought that partial resection of the stomach is comparable to simple mastectomy whereas "complicated" or "radical gastrectomy" is comparable to radical mastectomy wherein extensive lymph node and neighborhood structures are resected in an effort to remove or prevent metastases.

The high mortality for transthoracic resection may be due to the small number of cases or it may reflect the initial surgical experience with this procedure in this institution. More favorable progress is indicated by a recent report for this operation in this institution by Phemister and Adams of 33 transthoracic resections for carcinoma of the cardiac end of the stomach or the lower esophagus with 21 survivors; in a later series (Adams) there were 8 survivors in 10 such resections.

A mortality of 13.6 per cent was noted for exploratory laparotomy only. Palliative operations, gastroenterostomy, gastrostomy and jejunostomy, had a mortality rate of 26.1 per cent—the same as that for all types of resection and presumably not offering the degree of palliation provided by resection. Anschutz reports that palliative resection in his hands carried a 32 per cent mortality but allowed 54 per cent of 99 patients to survive 1 year, 21 per cent to survive 3 years, 8 per cent to survive 5 years, and 5 per cent to survive 8, 10, and 15 years. This suggests that more attention be focused on palliative resection as a substitute for gastroenterostomy, gastrostomy, and jejunostomy.

POSTOPERATIVE DEATHS

In 35 deaths following partial or total gastrectomy, 7 were associated with the extensive removal of other viscera because of neoplastic involvement; 18 followed total transthoracic or transabdominal gastrectomy. Fifteen patients died between the 1st and 3rd postoperative days; 16 between the 3rd and 7th days, 5 between the 14th and 21st days and 5 between the 21st and 29th days. Thus 31

patients, or 58.5 per cent of the deaths, died during the first postoperative week.

In 25 per cent of the patients dying postoperatively after resection, no detectable metastases were found at autopsy. This fact suggests that at least 25 per cent of the patients undergoing resection have a good chance of surviving 5 years or longer. In a recent report by Metheny (14) of 143 patients who died without operation, the lesion was confined to the stomach in 10 per cent and was theoretically curable by resection in 18 per cent.

Peritonitis, the chief cause of death (Table III) was due in some cases to suture leakage; in others the suture lines were intact. Pneumonia was the next important complication in 8 cases and directly caused death in 6. Other occasional causes of death were: shock from extensive operative procedures, mediastinitis, pulmonary embolism, pancreatic abscess, and granulocytopenia.

TABLE III.—CAUSE OF DEATH
GASTRECTOMY ALL TYPES

	Cases	Autopsies
Peritonitis	17	15
Cause not stated	11	0
Peritonitis and pneumonia	8	8
Pneumonia	6	3
Shock	5	1
Mediastinitis	2	2
Peritonitis and embolism	1	1
Embolism pulmonary	1	1
Pancreatic abscess	1	1
Granulocytopenia	1	1
Total	53	33

DISCUSSION

It is evident (Table I) that to a certain extent the indications for operation and resection in gastric cancer are matters of opinion, one report indicating that only 23.4 per cent of the patients were considered suitable for laparotomy whereas in another the figure is 89 per cent. Some clinics and groups with large experience lean toward the conservative view while other groups hold the more radical views. In this series the laparotomy rate was 83.5 per cent, higher than any we have found in the literature with the exception of the 89.9 per cent reported by Bocharov. Likewise, the resectability rate of 43.5 per cent was the highest found in the literature with the exception of the 44.6 per cent rate reported by Lahey. These figures probably reflect in part the difficulty in determining the possibility of resection without operation. The present trend is definitely toward a higher laparotomy rate and the acceptance of greater hazards in resection. This trend results from recognition of the following facts: (1) surgery offers the only hope of cure, (2) palliative resection is very much worth while, and (3) the mortality rate has progressively diminished in spite of the acceptance of greater hazards, the diminution being due to greater surgical skill, immediate prophylactic treatment of shock with transfusions of blood and plasma, and improved preoperative and postoperative care.

The factors responsible for the variations in resection mortality are not always available from reports. Livingston and Pack found only 3 instances in the United States, of published records of over 100 total gastrectomies for gastric cancer prior to 1939 and only 3,000 partial resections. Of all institutions reporting, 98 per cent had less than 2 resections per week while the great majority had less than 6 per year.

SUMMARY

1. Of 576 patients in whom the diagnosis of gastric carcinoma was made, 491, or 85.3 per cent, came for definitive advice and 466, or 80.9 per cent, accepted the advice.

2. In this group of 466, laparotomy was recommended and carried out in 389, or 83.5 per cent.

3. The resectability rate based on the 466 was 43.5 per cent; when based on the 389 submitted to exploration it was 52.1 per cent.

4. The resection survival rate based on the total of 466 was 32.2 per cent, when based on the 203 patients undergoing resection it was 73.7 per cent.

5. The mortality for gastric resection of all types was 26.1 per cent for the 17 years.

6. The mortality in unselected cases of partial resection was 22.6 per cent before 1940, 16.3 per cent after 1940.

7. Peritonitis continues to be the chief cause of postoperative death.

8. No residual carcinoma was demonstrated at autopsy in 25 per cent of the patients dying postoperatively from gastric resection.

CONCLUSIONS

The data herein presented seem to us to indicate:

1. A definite increase in the percentage of patients considered operable.
2. Higher resectability rates.
3. Lower postoperative mortalities in spite of the greater incidence of complicated and extensive operations.

Considerable progress is thus being made in the only treatment offering any real hope at the present time, namely surgical removal; nevertheless, the outlook for prolonged survival continues to be rather limited.

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BILATERAL AND MULTIPLE RUPTURED DISCS AS ONE CAUSE OF PERSISTENT SYMPTOMS FOLLOWING OPERATION FOR A HERNIATED DISC

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IT has been firmly established that the acute symptoms due to a herniated lumbar disc can be relieved by removal of the offending disc in most cases. Permanent relief of acute symptoms has also occurred in a large proportion of patients who have been able to avoid undue physical strain after operation.

On the other hand most surgeons will agree that recurrence or, less often persistence, of moderate to severe symptoms following operation for a herniated lumbar disc is by no means uncommon, especially when the patient has undertaken heavy work. The cause of these symptoms is usually obscure. In the great majority of instances they have occurred in patients who have been suffering from a solitary herniation which has apparently been adequately removed. Multiple herniations cannot therefore account for the symptoms in this group. In the present paper further observations (5) are presented, however, which support the belief that these recurrent or persistent symptoms may, at times, be due to the presence of bilateral or multiple ruptured discs which may be overlooked at the first operation.

In 1939 Camp, on the basis of myelographic studies, reported that in his experience 12 per cent of herniated discs were multiple. In the same year Love suggested that in order to avoid overlooking multiple discs it might be wise to use contrast media in all cases, even though protruded discs could be recognized clinically. Since then the occurrence of bilateral or multiple herniated discs has been reported by many observers (1, 2, 3, 6, 7, 8, 9, 13, and others). Childe has remarked, "Multiple disc herniations in the lower lumbar region are much more frequent than was originally supposed, and this is another strong argument in favor of routine myelography. All possible combinations exist and as many as six have been diagnosed in one individual." Dandy's observations in 1944 have served to focus our attention even more acutely on this problem for he has stated that, "Inspection of the spinal column explains the cause of defective lumbar discs, their frequency and the fact that they are nearly always multiple or potentially multiple. The high incidence of multiple discs is to be expected and actually obtains in practically all cases."

The problem of diagnosis and treatment in ruptured lumbar disc is far from solved. The present paper stresses one of the reasons why the problem is so complex and perhaps insoluble in certain cases.

In a report of a previous series of cases (5) it was re-emphasized that bilateral or multiple disc herniations may give rise to symptoms suggesting the presence of only a solitary unilateral herniation. For this reason a diagnosis based on clinical findings alone may be unreliable and it is believed that preoperative pantopaque myelographic studies (5, 12, 14, 15, 16, 17) are indicated in all these cases as a helpful adjunct to clinical diagnosis. That myelography also may fail to reveal a disc protrusion is, of course, well known. This fact makes it more apparent that multiple discs are even more common than has been demonstrated.

During the past 10 months (August 1944 to May 1945) 60 patients were operated on for a suspected herniation of a lumbar disc. In 56 of these cases one or more herniated discs were found. In the other 4 patients nothing abnormal was revealed at operation. The preoperative myelograms in the 4 cases had

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likewise been negative. These 4 patients all had low back pain with severe unilateral sciatic radiation of pain of long standing which had failed to respond to conservative treatment. Clinically it was felt that the patients probably had a herniated disc despite the presence of a negative myelogram and for this reason it was our opinion that they were entitled to an exploration. Pantopaque myelography which was carried out on all patients corresponded with the operative findings in 55. In 5 instances, however, ruptured discs were revealed at operation which had not been demonstrated by preoperative myelographic studies. In 2 of these latter cases myelography indicated the presence of a single herniation whereas at operation, as noted later, 2 discs were found to be herniated.

On the basis of clinical findings alone, each of the 60 cases, with 3 exceptions, was believed to have a solitary unilateral herniated disc. At operation, however, 1 patient was found to have 3 ruptured discs, 6 patients 2 herniated discs, and 3 patients a bilateral herniation of an intervertebral disc requiring bilateral removal. In 2 other patients, from each of whom a ruptured disc had been removed elsewhere by a competent neurosurgeon at the fifth lumbar level, a second herniated disc was found by us at operation to be present on the same side as the original exploration but in both cases at the interspace above. From another patient who had had a negative exploration elsewhere at the third lumbar level, we removed 2 herniated discs, one at the fourth and the other at the fifth lumbar interspace. In still another instance a herniated disc was extirpated at the fifth lumbar level on the left in a patient from whom a herniated disc had been removed elsewhere from the same interspace on the opposite side. These findings illustrate the relative frequency of occurrence of multiple ruptured discs and of bilateral herniated discs which required a bilateral approach for removal. There were 14 proved instances of multiple or bilateral discs requiring bilateral removal or 23.3 per cent of 60 cases and 10 proved instances of multiple discs or 16.6 per cent of 60 cases.

In addition to the cases mentioned 2 patients were found at operation to have what appeared to be a pathological "concealed" disc at one level and a definitely herniated disc at another level. Neither of these cases has been included in the series of multiple discs as no posterior protrusion could be demonstrated at the site of the so-called "concealed" disc and there was no evidence of root compression.

We would like to emphasize strongly here that an intervertebral disc is reported in this paper as being ruptured or herniated only when it has been proved to be so at operation. By herniated or ruptured we refer to a disc in which the nucleus pulposus has ruptured through the annulus fibrosis and, in addition, has caused a posterior protrusion sufficient to exert pressure on the nerve root. Those cases of "concealed" disc and those where definite posterior protrusion with nerve root compression was absent at operation have been excluded with 1 exception. The one exception is the final case reported in this series. We would also like to emphasize that all filling defects in the myelograms referred to as such in this paper have been proved at operation to be the site of a herniated disc.

The clinical myelographic and operative findings in the individual cases are of some interest.

With regard to the 3 patients in whom a bilateral herniation of a lumbar disc was present, pantopaque myelography revealed an almost complete block at the fourth lumbar level in the first case (Fig. 1), a bilateral filling defect at the lumbosacral junction in the second (Fig. 2), and a large bilateral defect at lumbar four interspace in the third (Fig. 3, a and b). Because of these myelographic findings a bilateral exploratory operation was carried out in the case of each of the 3 patients. This was accomplished in the usual fashion with removal of a minimal amount of bone from the laminae on each side, but the removal was always carried sufficiently far laterally to obtain the shelf of bone which so often overhangs the nerve root. In the first patient a large domelike protrusion was found markedly compressing the nerve root at the fourth lumbar interspace

on both the right and left side. The thinned posterior longitudinal ligament[1] was incised over the dome of the protrusion on the left and several small pieces of nucleus pulposus, which had herniated through the ruptured annulus were withdrawn by traction. A thorough extirpation of remaining nucleus pulposus tissue was then accomplished. The removal was carried across the midline after further retraction of nerve root and dura. Attention was then again turned to the disc herniation on the right and it was found to have been completely unchanged by the extirpation on the opposite side. This portion of herniated disc was then removed in similar fashion to that on the left. At the completion of this procedure it was found that the posterior longitudinal ligament had been incised, and intervertebral disc excised, directly across the midline. This had proved necessary before the posterior herniation of the disc on the right could be relieved. These findings demonstrated to us that when a bilateral herniation of an intervertebral disc exists, removal of the disc from a unilateral approach may not be sufficient to relieve the posterior herniation on the opposite side. In the second case with a bilateral herniation of the nucleus pulposus (Fig. 2) a similar bilateral exploration was performed but this time at the fifth lumbar level. Again a bilateral herniation of the disc was present with bilateral compression of the nerve root. The disc tissue in this case was considerably firmer than in the patient just described and was very difficult to remove. As in the first case, removal on one side had no apparent effect on the degree of herniation on the opposite side, although in this instance extirpation was not carried across the midline. The third case in this group of bilateral herniated discs presented a picture essentially the same as the other two. Myelogram showed a large bilateral filling defect (Fig. 3, a and b). At operation a large protrusion with definite compression of nerve root was visualized bilaterally before removal was attempted. The disc was then approached from the right side and found to be definitely herniated. The herniated portion of the nucleus was grasped with forceps and by means of traction as much tissue as possible was withdrawn. With the Cushing pituitary rongeur as radical a removal was then carried out as we are capable of doing. The rongeur was thrust downward into the depths of the intervertebral disc and tissue removed in a lateral and anterior direction at first, until all available material was obtained down to the firm fibrocartilaginous portion of the disc. The rongeur was then reversed and removal carried toward the midline and anteriorly until the nose of the rongeur again everywhere freely contacted firm resistance at the anterior limit of the disc. During this procedure the rongeur was at intervals angulated slightly in order to grasp any nucleus pulposus material adherent to the surface of the bodies. This method has proved more satisfactory in our hands than curretting the opposing surface of the vertebral bodies. This was regarded as rather a test case, and hence every effort was made to remove as much of the disc as seemed safely possible. Despite this radical removal on the right, the left-sided protrusion remained intact and had to be removed separately. This protrusion also proved to be a definite herniation of the nucleus pulposus. The large amount of disc tissue obtained from each side is shown in Figure 4. As previously stated, the clinical findings in the 3 patients just reported indicated a unilateral herniated disc. The first patient, however, did give a history of radiation of pain toward the right buttock on several occasions in addition to his usual severe pain which was distributed throughout the course of the left sciatic nerve. Following myelogram the pain began to radiate down the right leg as well as the left. The operative findings of bilateral root compression in the 3 cases cited, we feel, are very good evidence that none of these individuals might have been relieved of symptoms by a unilateral operation (at least in our hands) which would have been the case if clinical symptoms alone, without myelogram, had been relied upon.

It should be mentioned here that in 2 other cases in this series a bilateral protrusion of the disc, demonstrated in the myelogram and

[1]By longitudinal ligament reference is made to that thin membrane or capsule which usually overlies the herniated portion of the nucleus pulposus. This membrane is continuous with the longitudinal ligament but also forms the posterior layer of the annulus fibrosus.

visualized by bilateral exploration, was relieved by removing herniated disc tissue through a unilateral opening in the post longitudinal ligament. This demonstrates that all bilateral protrusions do not require a bilateral approach to reduce them, but it is believed that such an approach should at least be considered when there is evidence of bilateral herniations in the myelogram.

As to the patient with 3 herniated discs, myelography showed the presence of an almost complete block at the third, fourth, and fifth lumbar level (Fig. 5, a and b). Unilateral exploration on the right side (the side of his sciatic pain) was carried out at the three levels and three large herniations, which had markedly compressed a nerve root, were found. At the three levels nucleus pulposus tissue which had herniated through the ruptured annulus spontaneously extruded itself when the thin membrane was incised over the apex of the protrusion. A large amount of disc tissue was removed from each interspace. This patient's pain had been in the low back and had always radiated down the right leg. In addition to the other usual signs and symptoms of a herniated disc he had an absent right ankle jerk and a strip of diminished sensation to pin prick over the right lateral calf. A clinical diagnosis of herniated disc at the fifth lumbar interspace on the right side was made. This diagnosis, of course, overlooked the presence of additional herniations at third and fourth lumbar levels, which were demonstrated in the myelogram and proved to be present at operation. It is interesting that postoperatively the patient was free of right sciatic pain but continued to have slight low back pain and for the first time complained of pain down the distribution of the left sciatic nerve. From the myelographic findings of almost complete block at three levels, it seemed likely that this individual had not been completely relieved of his possible herniations on the left side. However, after a three months' interval he reports that he is now entirely free of sciatic pain.

It was stated above that in 6 patients 2 herniated discs were found. In 3 of these patients the clinical findings suggested a solitary unilateral ruptured disc. In 2 of the 3 cases myelography revealed 2 filling defects in the opaque material on the side corresponding to the patient's sciatica (Figs. 6, a and b, and Fig. 7). At operation a large herniation of the disc was found at the site of each filling defect. In the third case an almost complete block was demonstrated in the myelogram at the lumbar four level and a large filling defect at the lumbosacral junction (Fig. 8, a and b) on the right, the side of the patient's sciatic pain. A very large bilateral protrusion was found at operation at the fourth lumbar and a large protrusion at the fifth lumbar on the right. The operative findings leave no doubt that the fourth and fifth discs were definitely ruptured, at least on the right side. Both discs were removed from the right and it was not necessary for us in this case to open the posterior longitudinal ligament at lumbar four on the left as the nerve root here was observed to be decompressed by the right sided removal. The fourth case in this group was interesting. This patient was suffering from low back and left sciatic pain but his right ankle jerk was less active than the left. Myelogram showed a central defect at the level of the fourth lumbar disc, greater on the right, and another indentation of the pantopaque column at the fifth lumbar level on the right (Fig. 9, a and b). At operation a centrally ruptured disc was removed from the fourth interspace through a right sided approach and a laterally herniated disc from the fifth interspace on the right. The last 2 patients included in this group had symptoms of a unilateral disc at the lumbar five level. Myelographic studies indicated a solitary defect at the lumbar four level in each case but at operation a herniated disc was removed from both the fourth and fifth intervertebral spaces. It was because of conflicting clinical and myelographic findings that the patients were explored at the two levels.

Preliminary reference has been made to 3 patients who were operated on elsewhere for a herniated disc and from whom we subsequently removed another disc. The first of these 3 was operated upon overseas by a competent neurosurgeon. A myelogram was not performed prior to the original operation but the operative report leaves no doubt that

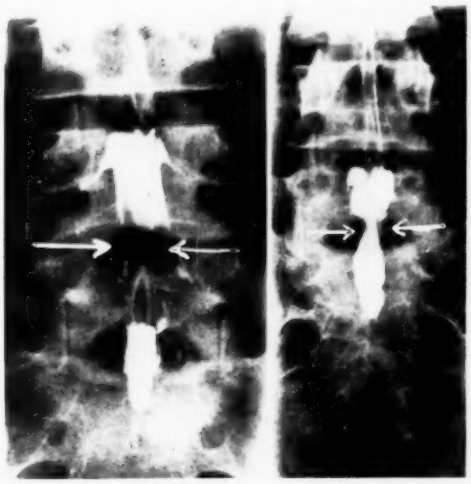
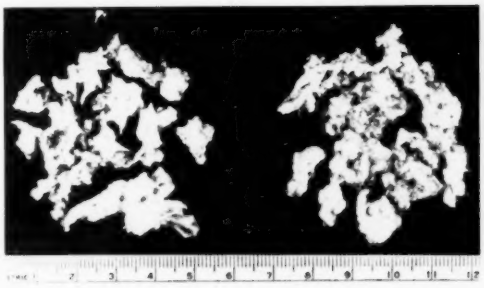


Fig. 1.

Fig. 2.

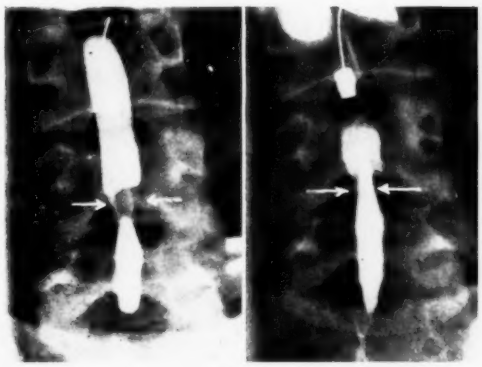


a Fig. 4. b

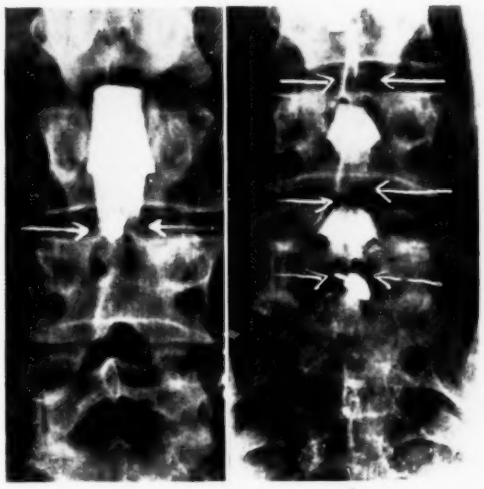
Fig. 1. This pantopaque myelogram shows an almost complete block at the fourth lumbar interspace (arrows). Pantopaque was injected at the third lumbar level and the patient placed in the upright position. Fluoroscopy and subsequent x-ray examination revealed that only a small amount of the material was able to trickle past the block and pool at the interspace below. At operation a bilateral herniation of the nucleus pulposus was found and a bilateral operation was required to remove it. Clinically the patient was believed to have a herniated disc only on the left side.

Fig. 2. A bilateral filling defect is seen at the arrows. This defect was constant as revealed by fluoroscopy and repeat x-ray films. A bilateral operation was necessary to extirpate a herniated disc which was found to be present on each side at this level (lumbar five). The clinical findings indicated a unilateral herniated disc.

Fig. 3. Myelogram, a, shows a complete filling defect at the level of the fourth lumbar disc. In myelogram, b, same patient, there is a bilateral filling defect at lumbar four interspace. Fluoroscopy left no doubt that a large bilateral defect was present. A bilateral herniation was found at operation and required a bilateral operation to decompress the nerve root on each side. A photograph of



a Fig. 3. b



a Fig. 5. b

the intervertebral disc material removed at operation is shown in Figure 4.

Fig. 4. The photograph shows intervertebral disc tissue removed at operation from the patient whose myelogram is seen in Figure 3. During the operation a herniation of the fourth lumbar disc was found on the right side and an attempt was made to remove as much as possible of the disc from a right sided approach. Photograph a shows the amount of material obtained. Despite this large extirpation of disc substance a marked herniation of the disc persisted on the opposite side and had to be removed through a left sided approach. Photograph b shows the amount of disc tissue obtained from the left side.

Fig. 5. a, The column of pantopaque stops abruptly at the third lumbar disc where an apparently complete block exists (arrows). The material was injected at the second lumbar interspace and the patient during fluoroscopy was left in the upright position for about 20 minutes but the pantopaque failed to descend below third lumbar inter-

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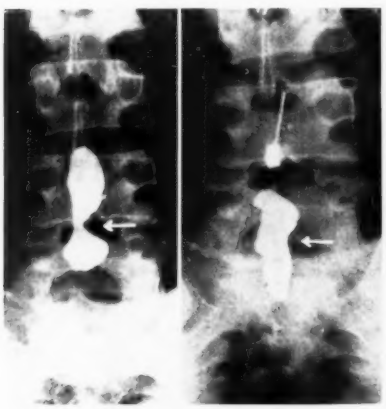
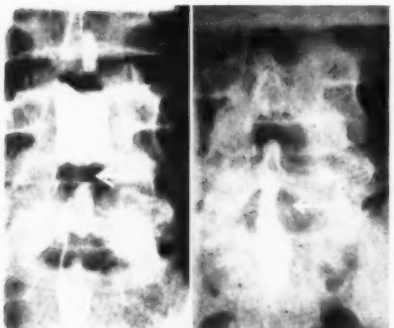


a Fig. 6. b

Fig. 7.



a Fig. 8. b

a Fig. 9. b

space. b, This is a myelogram done on the same patient several days later. The material was injected at lumbar five interspace and ran upward slowly. When the patient was again tilted into the erect position the pantopaque remained very nearly stationary, as shown, indicating an almost complete block at the third, fourth, and fifth lumbar discs (arrows). A large herniation of the disc was found at lumbar three, four, and five levels on the right (the side of the sciatic pain). The left side was not explored. Clinically the patient was thought to be suffering from a herniation of the fifth disc on the right. After myelography operation was postponed for several weeks as we thought at first we were dealing with a diffuse arachnoiditis.

Fig. 6. Two filling defects are revealed in this myelogram, one at the fourth interspace, a, and the other at the fifth, b. Fluoroscopy and repeat x-ray film revealed the defects to be constant and reproducible. Each filling defect outlined a herniated disc as proved at operation. The patient clinically was believed to have only one ruptured disc.

Fig. 7. A unilateral filling defect is seen at the site of the third (top arrow) and fourth (bottom arrow) intervertebral discs. A herniation of both the third and fourth discs was found at the time of operation, even though clinically the patient presented the signs and symptoms of a solitary ruptured disc.

Fig. 8. The patient on whom this myelogram was performed had a large herniation of the disc at lumbar four, a, and at lumbar five level, b. Fluoroscopy demonstrated an almost complete block at lumbar four interspace and a large unilateral filling defect at lumbar five (arrows). His clinical symptoms indicated a herniation of only the fifth disc.

Fig. 9. This is another example where myelography indicated the presence of two herniated discs in a patient who clinically was believed to have only one herniation. At operation a rupture of the fourth disc was proved to be present at the indentation of the pantopaque column as seen in a, and a herniation of the fifth disc at the site of the defect demonstrated in b.

Fig. 10.

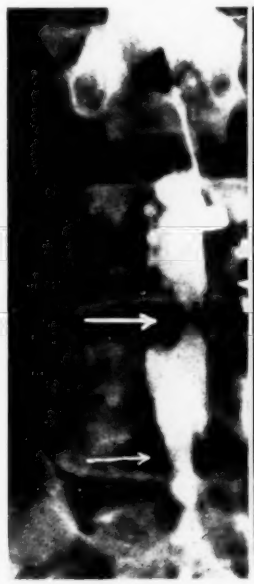


Fig. 11.

Fig. 12.

Fig. 10. Myelography showed a large filling defect at the level of the fourth lumbar disc on the right side (top arrow). The lower arrow points to the area of bone removal where a herniated disc (fifth lumbar) was extirpated previously. The patient had persistence of symptoms on the right side following the initial operation. At a second operation a large herniation of the disc was found at the site of the filling defect.

Fig. 11. The filling defect noted at the level of the fourth lumbar disc (top arrow) outlines what proved at operation to be a large herniation of the disc. The patient on whom we performed this myelogram had had a protruded disc removed elsewhere from the fifth lumbar interspace (bottom arrow).

Fig. 12. Filling defects are present in the pantopaque column at the level of the fourth (middle arrow) and the fifth lumbar discs (bottom) arrow. Herniated discs were found at the site of each filling defect. The patient had had a negative operative exploration done elsewhere at lumbar three level (top arrow).

there was a large herniation of the disc at the fifth interspace on the right side, and that this disc was removed. Following this procedure the patient continued to complain of low back and right sciatic pain although he believed this to be somewhat less severe than before operation. A pantopaque myelogram (Fig. 10) was performed by us and revealed a large filling defect on the same side as the original exploration but at the interspace above. At a second operation we removed a disc from the fourth interspace, which was markedly herniated and which caused severe pressure on the nerve root. The history of the second patient was very similar to the one just mentioned and also similar to a case reported by Echols. An accomplished neurosurgeon had removed what, from the operative report, appears to have been a definitely ruptured intervertebral disc at the fifth lumbar interspace. The patient had complete relief of symptoms for a short period but during bicycle riding had a severe recurrence of his old symptoms. We performed a myelogram (Fig. 11) which revealed filling defects at the site of the old operation and also at the interspace above. At a second operation a large herniation of the disc was found at lumbar four level and extirpated with relief of symptoms. In this case it is possible that the herniation of the fourth lumbar disc occurred after the original operation. However, since no myelogram was performed initially, one is left in doubt concerning this possibility. The third patient in this group had been explored by an excellent surgeon overseas at the third lumbar interspace which he had mistaken for the fourth. His exploration was negative and

the patient continued to complain of symptoms. In a subsequent myelogram (Fig. 12) unilateral filling defects were present at the level of the fourth and fifth discs, on the same side as the first operation. At a second exploration we found a ruptured disc at the site of each filling defect.

The final case in the series was a patient who had a herniated disc removed by a well known neurosurgeon overseas from the fifth lumbar interspace on the right. As a result of this his right sciatic pain disappeared but he continued to complain of low back pain and later of pain down the left sciatic distribution. Myelogram was performed and revealed nothing abnormal. The orthopedic service, on good evidence, believed that spinal fusion might help this man and this was accordingly carried out. During the procedure one of us was asked to explore the fifth interspace on the left side. This was done. The posterior longitudinal ligament was found to be bulging slightly and on palpation felt soft and rubbery. It could not be stated definitely that the nerve root in this case was compressed at the time of exploration. However, on incising the post longitudinal ligament the deeper portion of the annulus fibrosus was found to be ruptured and a piece of intervertebral disc of "Y" shape, each limb of the "Y" measuring approximately 1 by ½ inch, was lifted out of the intervertebral space. This very large piece of intervertebral disc was completely unattached to surrounding tissue and lay free in the intervertebral space between the bodies. (It should be noted that this is the only case included in the group of multiple or bilateral discs in which evidence of nerve root compression was lacking.)

COMMENT

Experience in the Army has not proved the problem of herniated disc to be a simple one. Recurrence, or less often persistence, of moderate to severe symptoms, both organic and functional, following operation has been only too frequent, especially when the individual has been required to do heavy work. In the Army a functional element has probably played a greater rôle in precipitating these symptoms than in civilian life, but in many patients the causative factors are not clear or at least there is a wide difference of opinion concerning their etiology (11). The great majority of patients who have presented such symptoms have suffered from a solitary herniated disc which was apparently adequately removed. As pointed out multiple herniations cannot therefore account for the symptoms in this group. It is believed, however, that the series of cases reported illustrate that bilateral 6.6. per cent of 60 cases or multiple 16.6 per cent of 60 cases herniated discs, which may be overlooked at the first operation, may at times account for these persistent or recurrent symptoms.

Clinical findings alone will usually fail to indicate the presence of more than one herniated disc and therefore cannot be safely relied upon to disclose the multiple lesions under discussion. Myelographic studies with pantopaque are very helpful in revealing the presence and level of such lesions and in our opinion are indicated in all cases before operation. This procedure, however, may occasionally also fail to reveal a ruptured disc, especially when it lies far laterally. In the presence of a negative myelogram, decision to operate will depend upon the severity of the symptoms and whether or not the clinical picture is characteristic of a herniated disc. Likewise decision to explore multiple defects will depend upon their nature, the patient's symptoms, and the surgeons' clinical judgment.

In selecting cases of suspected herniated disc for myelography we have adhered to a conservative policy. Only those patients with intractable, characteristic symptoms of herniated disc, who have not responded satisfactorily to conservative orthopedic measures have been subjected to this diagnostic procedure. No patients have been operated upon without it. We believe that this is sound policy. As a result we were dealing with relatively severe cases and this may explain in part the high incidence of multiple herniations.

It should be emphasized that although the removal of multiple ruptured discs will usually relieve acute symptoms, heavy work is prob-

ably more likely to precipitate postoperative symptoms in this group than in patients who have required the removal of only a single disc. The fact that multiple discs are relatively common therefore only emphasizes the complexity of the problem.

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METASTATIC HYPERNEPHROMA OF THE THYROID GLAND

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THE rarity of metastases to the thyroid gland from primary malignant foci elsewhere in the body is well recognized.

Willis in 1931 reviewed the literature in reference to metastatic tumors of the thyroid. He collected 47 cases and added 10 more of his own. His cases were taken from 170 consecutive autopsies in patients who died of malignant disease—an incidence of 5.9 per cent. Other series of autopsies in cases of extensive carcinoma which he collected gave percentages varying from 1.5 (15) to 3.1 (7). Rice found, in a series of 89 autopsies on patients who died from malignant tumors, 9 or 10 per cent of the thyroids showing metastatic tumor cells. These could be seen grossly in 5 cases and were found only on careful microscopic sectioning in the other 4. He stressed the need for more careful study of the thyroid gland in such autopsies. Mayo and Schlicke, in 1941, reviewed all the cases of metastases to the thyroid which had been encountered at the Mayo Clinic. They found 19 cases and in 3 the diagnosis was made from thyroid specimens removed at operation. Two of these cases were metastases from hypernephromas and one from a carcinoma of the rectum. Seven cases had thyroid abnormalities noted before death and the remaining 9 cases were encountered during routine autopsy examination. The total number of autopsies done was not given, but in more than 45,000 cases in which thyroidectomy was performed only 3 metastatic lesions were found.

Explanations for the infrequency of metastases in the thyroid have been sought in 2 directions; one group postulating that the very rich arterial supply inhibits the lodgment of emboli in the gland, while others were of the opinion that the rarity is due to chemical factors which hinder metastatic growth. Paget spoke of some tissues which he considered "congenial soil" for malignant tumors. The high oxygen and high iodine content of the gland may be factors which inhibit the development of malignant cells. In contrast the relatively low oxygen saturation of liver tissue may predispose to the frequency of neoplastic spread to this organ. Warburg has

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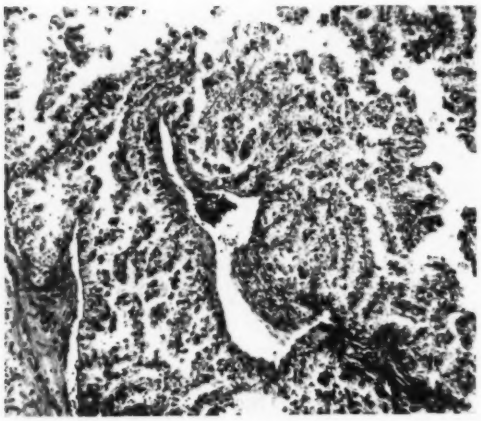

Fig. 1. A photomicrograph from the original hypernephroma. The tumor was removed when the left nephrectomy was performed in 1936. The cellular structure is similar to that seen in Figures 3 and 4.

pointed out that tumor cells can grow at a relatively low oxygen tension.

Willis concluded that chemical factors largely explain the scarcity of metastatic lesions in the thyroid. He found that in several of his cases adenomatous and fibrous changes in the thyroid had preceded metastases and he felt that the lower oxygen and iodine content predisposed to the establishment of these metastases. Similarly, Mayo and Schlicke found underlying adenomatous changes in 12 (and perhaps in 4 others) of their 19 cases. The thyroid in the case presented here also showed the same underlying pathology. It seems to us, however, that such changes in the thyroid gland tend to support the theory that the rich blood supply of the organ hinders the lodgment of tumor emboli, since fibrotic areas and degenerating adenomas probably have a reduced blood supply compared to normal thyroid tissue, so that the tumor emboli may be deposited more readily in these areas. It also seems probable that the sieve-like action of the lungs is an important factor in decreasing the number of tumor emboli which might otherwise lodge in the thyroid. Willis further found in his series that malignant melanomas and primary lung carcinomas, although relatively uncommon tumors, were found to have metastatic foci in the thyroid in a proportionately higher number of cases. He concluded from the data that different types of tumors possess different intrinsic capacities for establishing metastases in the thyroid. Miller and Jones, however, collected 808 cases of primary lung cancer and found only 8 cases in which there were metastases to the thyroid, an incidence of only 1 per cent.

A review of the literature reveals that only 15 proved cases of metastatic hypernephroma of the thyroid have been reported. Since this lesion is of such rarity it seems justifiable to report an additional case.

According to H'Doubler the first 5 cases were reported in the European literature. These were by Lubarsch, in 1894, Kodzubowski, in 1904, Pistocchi, in 1922, Rost, in 1912, and Klose, in 1925. The first 3 cases were recognized clinically, but the last 2 were discovered on routine autopsy. Since 1931, 10 additional ones have been reported, 9 in the American literature and 1 in the French literature. Kolodny, in 1926, reported a case which he considered metastatic hypernephroma of the thyroid with an accompanying clinical picture of exophthalmic goiter, but considerable doubt has arisen in regard to the case. The gland was removed and found to contain many circumscribed yellowish white nodules which Kolodny believed on microscopic examination to be metastatic hypernephroma. The patient, however, remained in good health with relief of her symptoms and no primary tumor was found. This case on further analysis probably was not a metastatic hypernephroma and, therefore, is not included in the group of cases reviewed here, especially since Simpson, in 1926, reported 8 cases out of a group of 55 malignant thyroid glands in which he found microscopically groups of cells that simulated hypernephroma. He concluded that Kolodny's case represented this type of tumor.

Willis, in 1931, reported the first authentic case in the American literature of metastatic hypernephroma of the thyroid gland. The condition was discovered on postmortem examination. The thyroid gland was found to show fibrosis and parenchymatous atrophy. Pemberton and Bennett, in 1934, reported 2 cases from a series of 45,421 surgical thyroid

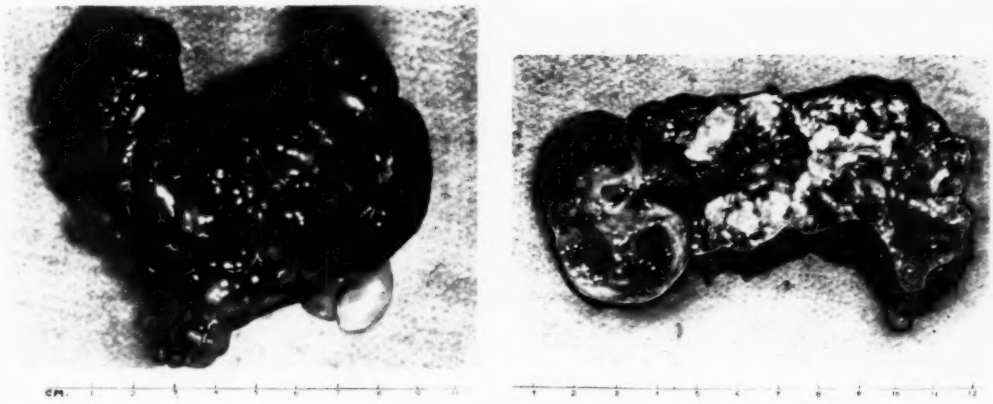

Fig. 2. a, left, A photograph of the entire thyroid gland removed in one piece at operation on April 13, 1944. Note the lobulated appearance of the specimen. b, A photograph after section of the specimen to show the metastatic nodules of tumor tissue throughout the substance of the thyroid gland.

specimens removed at the Mayo Clinic between 1892 and 1932.

H'Doubler, in 1936, reported 2 cases. The first, a man aged 59 years, presented the classical symptoms of hyperthyroidism with a basal metabolic rate of plus 46. One year previously he had noted bloody urine. Physical examination showed an enlarged right lobe of the thyroid gland. This was removed at operation and was found to be a canary yellow nodule, which on histologic examination proved to be typical of hypernephroma. The patient died 3 years later from generalized metastatic renal cell carcinoma. The second, a woman aged 73 years, complained of choking spells and a goiter. Six years before, a hypernephroma of the right kidney had been removed. She had noted a lump in her thyroid gland 3 years later which had gradually increased in size. Physical examination showed an enlarged, firm right lobe of the thyroid gland. An operation was performed, at which the right lobe, the isthmus, and an accessory nodule were removed. One and a half years later a nodule developed in the left lobe. She died 4 years after the operation of generalized metastases.

Caylor and Caylor, in 1936, reported 1 case, a man aged 59 years, who had had a transperitoneal nephrectomy for hypernephroma. Thirteen years later, at operation, an inoperable metastasis was found in the thyroid gland. He was given roentgen therapy with some improvement.

Weiskittel, in 1937, reported 1 case among 10,000 thyroidectomies at the DeCourcy Clinic. The patient, a man aged 60 years, 8 years previously had had a right nephrectomy for a hypernephroma. He later noted a painless swelling of the neck. Physical examination revealed an enlarged, firm thyroid gland. A basal metabolic rate was plus 32. At operation a large metastatic renal cell carcinoma was removed. The wound was packed open because of extensive bleeding. He was given postoperative roentgen therapy but died 9 months later.

Fey and Truffert, in 1938, reported a case that had succumbed to extensive metastatic hypernephroma and necropsy revealed involvement of the thyroid gland. It is of interest that 16 years before a thyroid adenoma had been removed.

Welti and Huguenin, in 1939, reported 1 case of metastatic hypernephroma in a series of 88 cases of thyroid malignancy. The patient presented mild symptoms of hyperthyroidism. One kidney had been removed 10 years before for carcinoma. The patient died later of extensive metastases.

Long and Black, in 1945, reported a third case from the Mayo Clinic. The patient, a man aged 59 years, complained of a slowly enlarging goiter of 1 year's duration. Eight

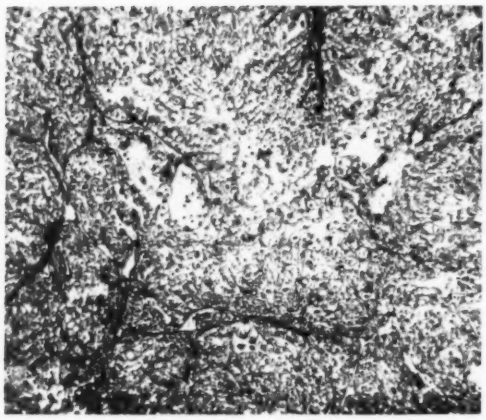

Fig. 3. A photomicrograph from one of the metastatic nodules from the thyroid gland. Note the similarity in appearance between the cellular structure of this specimen and the ones shown in Figures 1 and 4.

Fig. 4. A photomicrograph from biopsy tissue from hypernephroma of right kidney removed September 22, 1944. Note similarity of cellular structure to that of original tumor (Fig. 1) and thyroid metastasis (Fig. 3).

years previously a nephrectomy had been performed for a hypernephroma. Physical examination revealed a diffusely enlarged thyroid gland of soft consistency. A resection of both lobes and the isthmus was performed. The histologic examination revealed metastatic hypernephroma. Postoperative roentgen therapy was administered.

CASE REPORT

Frank C., a man aged 55 years, was admitted to The Baker Memorial Hospital on March 30, 1944, complaining of swelling in the neck, ease of fatiguability and weight loss, of about 6 months' duration.

About 6 months before entry following a severe upper respiratory infection, he noted the insidious onset of increasing ease of fatigue and was troubled with persistent left frontal headaches which were aggravated on lying down. He lost his appetite, became "nervous and irritable" and about 4 months before entry began to note a slowly increasing swelling in his neck. His weight fell from a normal of 204 to 186 pounds. During the month previous to admission the swelling increased rapidly and he began to have a "scratchy" feeling in his throat on swallowing but had no real hoarseness or dysphagia. He noted no tremor, palpitation, or increased prominence of the eyes.

Because of the cervical tumor, he was studied first in the hospital in which he worked. There it was found that his blood examination was within normal limits; his blood pressure was 116 systolic and 70 diastolic. His basal metabolic rate was minus 3. The blood cholesterol was 140 milligrams per cent. A barium enema, a cholecystogram, and a gastrointestinal series of roentgenograms were all negative. Intravenous pyelography showed an enlarged right kidney. No shadow was seen on the left which was consistent with his left nephrectomy 9 years previously. After the completion of these studies he was referred to The Baker Memorial Hospital for further study and treatment with a presumptive diagnosis of thyroiditis.

The patient was born in Portugal, coming to the United States at the age of 13 years. For several years he worked at varied occupations but for the past 26 years he had been a mechanic in a hospital. He had been married 31 years; his wife was living and well. They had had one child who died at birth. Nine years before this hospital admission a left nephrectomy was performed by Dr. C. L. Deming at the William Backus Hospital in Norwich, Connecticut. A renal cell carcinoma of the hypernephroma type was diagnosed pathologically (Fig. 1). He recovered uneventfully from the operation and, until his present illness, had enjoyed good health. He had had no other operations or serious illnesses. His system review was negative except for chronic sinusitis and a slight chronic nonproductive cough. He had occasional nocturia, but noted no hematuria or frequency. He smoked about ten cigarettes a day but did not use alcohol.

His family history was noncontributory and he knew of no familial incidence of cancer, tuberculosis, heart disease, diabetes, thyroid disease, or allergies.

Examination showed a well developed and nourished man with an obvious enlargement in his anterior cervical region, which was consistent with a symmetrical, diffusely enlarged thyroid gland with a slightly irregular outline. The gland was firm, but not stony hard and moved normally on swallowing. No regional nodes were palpated and no bruit was

present. The patient showed no signs of hyperthyroidism or hypothyroidism. Examination of the abdomen revealed a movable, nontender, rounded mass in the region of the right kidney, which descended to the level of the iliac crest on respiration. Physical examination was otherwise negative.

Red blood count was 4.54 million; photohemoglobin, 13.2 grams per cent; white blood count, 8,600; the blood smear showed normal platelets, red and white blood cells. Urine examination showed specific gravity 1.008 to 1.020; one plus albumin; negative sugar; sediment, 0-20 red blood cells, 3-20 white blood cells and an occasional hyaline cast per high powered field, and a negative culture. A phenolsulfonphthalein test showed 20 per cent excretion of the dye in 15 minutes and a total of 66 per cent in 2 hours. Blood chemistry examinations showed: nonprotein nitrogen, 27 milligrams per cent; fasting blood sugar, 119 milligrams per cent; cholesterol 266 milligrams per cent; calcium 8.8 milligrams per cent; phosphorus, 3.3 milligrams per cent; serum protein 7 grams per cent. The prothrombin time was normal and the blood Hinton test was negative. The basal metabolic rate was minus 3. Roentgen examinations revealed the following: The chest plate showed a slightly enlarged heart in the region of the left ventricle, but no evidence of substernal goiter. Retrograde pyelograms showed the right pelvis well outlined. The infundibula were narrowed with an appearance of crescentic pressure. The kidney shadow showed marked general enlargement with a slightly lobular contour. A diagnosis of congenital polycystic kidney was considered to be the most likely diagnosis from study of these roentgenograms.

Diagnosis: Malignancy of the thyroid gland.

On April 13, 1944, operation was performed. Endotracheal ether anesthesia was used. Through a transverse collar incision, an enlarged vascular thyroid gland was exposed. Biopsy specimens showed yellowish tissue, suggestive of hypernephroma. The right lateral thyroid vein was found to be filled with tumor-like tissue and accordingly it was believed that the thyroid enlargement was due to malignant growth, so a total thyroidectomy was performed. The recurrent laryngeal nerves and two parathyroid glands were visualized and preserved. The tumor was not adherent except over the cricoid cartilage. No enlarged nodes were seen or felt along the carotid sheaths and the lateral thyroid veins were ligated proximal to any obvious tumor; hence a radical neck dissection was not felt indicated. The wound was closed in layers without drainage. Cotton ligatures and sutures were used for hemostasis and wound closure.

Pathological examination of the specimen showed a 7 by 2 by 1.5 centimeter gland which weighed 70 grams. It was made up of round, soft, lobulated yellow-orange nodules measuring 0.5 to 2.0 centimeters in diameter. The right middle and inferior thyroid veins were filled with similar tissue (Fig. 2). The thyroid tissue between the nodules was red-brown, firm and meaty. Microscopically the tissue was consistent with renal cell carcinoma (Fig. 3).

The immediate postoperative convalescence was uneventful except for slight transitory tetany that responded to peroral administration of calcium gluconate. Postoperative roentgen ray therapy to the cervical region was not advised by the x-ray department, so the patient was discharged from the hospital on April 26, 1944.

Following his discharge he developed myxedema which responded to the administration of thyroid extract. He remained fairly well at home except for severe headaches and pains in his cervical spine.

He was readmitted to The Baker Memorial Hospital on September 13, 1944, 4½ months after his first discharge, complaining of an increasing mass and pain in the right side of his abdomen. Physical examination showed the patient still in a good state of nutrition. His thyroidectomy scar was well healed. No evidence of recurrence of the tumor was found in his neck. The mass in his right flank had enlarged considerably.

Laboratory studies at this time showed red blood count, 3.85 million; photohemoglobin, 10.3 grams per cent. Urine examination revealed: specific gravity, 1.012; negative albumin and sugar; sediment, occasional white blood cells and no red blood cells. Blood chemistry examinations revealed: nonprotein nitrogen, 33 milligrams per cent; calcium, 6.8 milligrams per cent; phosphorus, 5.2 milligrams per cent and serum phosphotase, 2 units (Bodansky). Roentgen examination of the chest and cervical spine was negative.

On September 22, 1944, with patient under ether anesthesia, the right kidney was exposed by Dr. James D. Barney. A large renal tumor was found that could not be removed. A biopsy specimen was taken which showed renal cell carcinoma (Fig. 4).

The postoperative course was uneventful. He was given palliative roentgen-ray treatment over his right kidney to a total of 1200 r each to anterior, posterior, and lateral fields.

The latest report from the patient was 6 months following discharge. At that time he stated that he felt well and wished to return to work.

This case, as far as can be determined, is the 16th case of metastatic renal cell carcinoma to the thyroid to be reported in the literature. Several of these, however, were found on routine autopsy and undoubtedly there have been others which have not been reported. Those cases in which the goiters were recognized clinically and upon which operation was performed are of extreme interest. Such a condition must be considered as a possibility in the differential diagnosis of thyroid tumors, especially in those patients who have previously had surgery performed for malignant growth.

The question of the manner in which metastatic emboli reach the thyroid from the kidney is still obscure, since if it is by the blood stream these organs are separated by the extensive capillary bed in the lungs. The persence of a patent foramen ovale is one possibility whereby tumor cells could by-pass the pulmonary circulation to produce a paradoxical metastasis. The work of Batson has postulated the vertebral system of veins as another pathway by which such metastases may travel without going through the lungs. This also could be an explanation of the lack of pulmonary metastases in this and similar cases.

In the case reported the fact that a hypernephroma was found in the right kidney 9 years after a left nephrectomy had been done for a similar type of tumor, is of interest. This could be interpreted as a case of bilateral primary hypernephroma, although it is likely that the tumor in the right kidney was a metastasis from the original lesion. Forsythe, in 1942, reported a case of bilateral hypernephroma and found only 6 other cases, some of which were probably metastatic lesions rather than separate tumors. Beilin and Neiman in the same year reported another case and stated that direct metastasis from one kidney to the opposite is unusual. The origin of the thyroid metastases in the case reported may have been from either the right or left kidney, since the microscopic examination of the 3 specimens is identical. In view of the lapse of 9 years between the removal of his left kidney and the discovery of thyroid metastases, it seems most likely that they arose from existing tumor of the right kidney. The rapidity and the recentness with which the enlargement of the thyroid gland manifested itself tend to substantiate this view.

SUMMARY

A case of metastatic hypernephroma to the thyroid gland, the 16th proved case in the literature, is reported. It is the first case observed in the records of the Massachusetts General Hospital. It is unusual in that the first sign of metastases occurred 9 years after a left nephrectomy for a hypernephroma and coincidental with the discovery of a similar tumor involving the right kidney.

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MALFORMATION OF THE ANUS AND RECTUM

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FROM December 1936 to December 1945, there were 20 patients with malformation of the anus and rectum admitted to Doernbecher Hospital. Of these, 11 were males and 9 were females. The incidence of all admissions for this period of time was 0.14 per cent.

The probable cause of this condition is some arrest or abnormality, which takes place in the 7th or 8th week of embryonic life. The details of these abnormalities and embryonic development have been clearly discussed by Ladd and Gross.

There are four distinct types of imperforate anus, ranging from simple stenosis to complete atresia of the anus and rectum. Figures 4a, 5b, 6a, and 7 are examples of these types.

The most common type in our series (as seen in Fig. 5b) was an absence of the anal opening in which the blind rectal pouch was only ½ to 2 centimeters from the perineal dimple. We had 6 such cases in our series. These were most amenable to surgery and in every case good results were obtained.

In most of the cases in our series of complete absence of the rectum, where the rectal pouch was 2 to 3 centimeters from the perineal dimple, an associated rectovaginal fistula was present with a fistulous tract extending from the rectal pouch to the vagina near the posterior fourchette.

Seven of the 20 cases were of this type. In 5 of the 7 cases repair was made by dissecting away the fistulous tract and bringing the rectal pouch down to the anal dimple by cutting through the sphincter and making a new outlet. In 1 case repair was not made and in 1 other case a colostomy was necessary, then later, the rectal pouch was brought down to the anal dimple and the colostomy closed.

There were 2 cases of anal stenosis in which obstructive symptoms were outstanding and dilatation rather than surgery were the only procedures necessary (Figs. 6 and 6a).

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One patient (L. W. No. 141451) had complete absence of the rectum—yet the perineal dimple had a deep indentation of approximately 2 centimeters (Fig. 4a). The rectal pouch was so far (3 centimeters) from the perineal dimple that the rectum could not be brought down and a colostomy had to be done. When the distance was 3 centimeters or over from the gas-filled rectum to the anal dimple, colostomies were done. There were 4 such cases in our series.

There are certain practical points to be stressed as a result of study of these cases.

The importance of determining in advance the distance between the perineum and the blind end of the bowel should be emphasized because the perineal dissection should not be persisted in, in cases in which the bowel is further than 2½ centimeters from the perineum. The best method of determining this distance is described by Wangensteen and Rice. Anteroposterior and lateral x-ray films are taken with the baby in the upside down position with a metal marker in the anal dimple. If 8 hours have elapsed since birth, presence of gas in the rectal pouch will show the distance of the blind end of the bowel from the perineum. If the distance is less than 2½ centimeters the bowel may be readily brought down to the perineum in most cases. If higher, perineal dissection may be attempted but if one is unsuccessful in finding the lower end of the bowel, the dissection should not be prolonged and colostomy should be done.

Any case of rectovaginal fistula or rectoperineal fistula can be brought down from below. This is not true of rectovesical or rectourethral fistulas—the fistula in these latter cases should be repaired later in life.

A noteworthy point is the frequent association of other congenital deformities with these deformities of the anus and rectum. The following table shows the different abnormalities encountered in these cases: cataracts, 2; strabismus, 1; rectovaginal fistula, 7; rectovesical fistula, 1; congenital heart, 3; atresia of esoph-

agus, 1; hypospadius, 1; absence of radius, 1; absence of urethra, 1; undescended testis, 1; megalocolon, 1; double pelvis, 2; ectopic kidney, 1; hydroureter, 2; umbilical hernia, 1; absence of digits, 2; absence of external ear, 1. The only immediate postoperative death in this series was a child with absence of the urethra as well as the anus. Four other patients who died at dates ranging from 3 months to 2 years following surgery all had anomalies of the urinary tract.

The following are abstracts of the cases in our series.

CASE REPORTS

R. H., Case No. 138372, was born April 6, 1944, and admitted to Doernbecher Hospital April 7, 1944 for surgery. This child was born with an imperforate anus. On April 8, 1944 patient was taken to surgery. There was an unopened mucus-like channel (Fig. 1) running from the region of the imperforate anus to the base of the scrotum. This was tube-like in character, very narrow, and was filled with inspissated meconium. It was dissected up from the scrotum and an incision made at the anus in the anterior posterior direction and a large quantity of meconium was evacuated. Several other abnormalities were found in this child. Fingers were peculiar. There was a harsh systolic murmur at the apex. There was a small tumor on the external ear. The child was discharged on April 12, 1944. Now child has excellent sphincter control and is in good condition.

N. W., Case No. 123194, 3½ week old child, was admitted to the hospital on November 24, 1941 with a congenital absence of the anus and a rectovaginal fistula (Fig. 2). The fistula had apparently been sufficient for fecal outlet as the child had no history of obstruction and had been developing normally since birth. The mother had been cleaning the bowel out by catheterizing the fistulous tract. Physical examination revealed a well nourished child, whose only abnormality was of the perineum and genitalia. There was no anus present; just an anal dimple where the opening should be. There was a fistulous tract just inside the posterior fourchette which apparently communicated with the rectal pouch. Anteroposterior and lateral x-ray films of the pelvis, after injection of barium through a rectovaginal fistula by means of a rubber catheter, were taken. The rectum was well visualized, ending in a blind pouch, which is approximately 2 centimeters from the imperforate anus which is marked by small opaque marker. It was the opinion of the surgical staff that surgery should be deferred until a later date because of the mechanical difficulty involved in such a small child. Patient was discharged and the mother was instructed to keep the stools soft with mineral oil. Patient returned July 25, 1943, was taken to surgery where an incision was made through the anal dimple and through the sphincter muscles up to the levator. Dissection was then carried around the rectum on each side and when this was complete the mucous membrane at the rectovaginal junction was incised and the entire anal rectal canal was transplanted to the perineum. The vaginal mucosa was repaired. The child made an uneventful recovery except for a retrovaginal defect which remained. The child's hospital stay was 15 days, being discharged on August 13, 1943. Further repair to be considered in the future. Later repair was done with satisfactory closure of the rectovaginal opening. Since this time patient has been asymptomatic.

K. P., Case No. 129015, 3 week old white female, entered Doernbecher Hospital January 4, 1943 with imperforate anus and a rectovaginal fistula (Fig. 2). The child was taken to surgery where the rectovaginal fistula was dissected and closed; and the distal end of the rectum was brought through the anal ring and the mucosa sewed to the skin. The rectal pouch was about 2 centimeters from the anal dimple. The child had a very stormy course postoperatively, but apparently recovered and had good sphincter control. However, on August 9, 1943 the child was admitted to the hospital with a terminal urinary tract infection. Autopsy showed bilateral hydroureters and hydronephrosis with a supprative pyelonephritis.

D. E., Case No. 127337, 4 day old white male, entered the hospital on July 5, 1942 because of an imperforate anus. Examination revealed a well nourished white male infant. The abdomen was quite distended and taut. No hernia was detected. No abdominal mass was palpable. The anus was found to be imperforate. Remainder of the examination was essentially negative. X-ray examination revealed the heart and lungs normal. The abdomen revealed a large amount of free gas in the peritoneal cavity with the shadow of the small bowel containing air clearly visible (Fig. 3a). On August 7, 1942 the child was taken to surgery. The abdomen was opened whereby a large amount of air came through the incision. A large amount of yellowish material with fibrin flex was present in the abdomen. In the lower right quadrant of the abdomen there was a distended, necrotic portion of bowel. On examination this section of bowel revealed a small rupture through which much meconium has passed into the abdominal cavity. A rubber drain was passed beneath the bowel at this point and was delivered to the surface where it was exteriorized and the abdomen closed. The child showed a slow gradual improvement with a slow progressive weight gain. On August 7, 1942 barium meal was given. The esophagus, stomach, and duodenum were normal. Also the barium was injected in the distal loop of the colostomy. The roentgenographic findings were very suggestive of an occlusion or stenosis of the distal sigmoid approximately 4 centimeters above the anus (Fig. 3b). Inspection of the proximal loop of the colostomy revealed it to be sigmoid colon. At the time of discharge on August 24, 1942 the child

was showing a progressive weight increase, weighing 7 pounds 13½ ounces. His general condition was quite good. The child was readmitted on October 4 1942. Since his discharge following surgery for imperforate anus he seemed quite well until 4 days before when he began to vomit. He had had no difficulty with the colostomy opening since his discharge. Physical examination at this time revealed a patent and functioning colostomy opening. The tissue around this area was redundant and inflamed. The child went rapidly downhill and died on October 10, 1942, 3 months after colostomy. Autopsy findings revealed: atresia of the lower rectum and anus; double-barrel colostomy, functioning, of the left lower quadrant; bilateral interstitial nephritis and left pyelitis and hydroureter.

D. H., Case No. 68466. This child entered the Doernbecher Hospital for the first time at the age of 3½ months. Since birth patient had had a rectovaginal fistula with imperforate anus (Fig. 2). The child returned for surgery at age of 4½ years. At the operation a rectovaginal fistula was dissected. The vaginal opening was closed and the rectal pouch brought to the anal dimple and the mucous membrane was sutured to the skin. The rectal pouch was 3 centimeters from the anal dimple. The child made an uneventful postoperative recovery and has had normal sphincter control. Dilatations were continued at home; the child has been seen in out patient clinic since 1941 and has had no further trouble.

A. J., Case No. 105727, 8½ hour old white male entered the Doernbecher Hospital with an imperforate anus. X-ray films were taken by the Wangensteen-Rice method and the rectum appeared to be 3 centimeters from the anal dimple (Fig. 4a). The child also had a hypospadias. Colostomy was done on January 13, 1940 and the child recovered uneventfully, yet, 1 month later the child returned to the hospital with a high fever and a methylene blue injection was given through the distal loop of the colostomy and it appeared in the urine in 2 hour proving the presence of a rectovesical fistula. The child was discharged and given a poor prognosis. Surgery was impossible due to the child's poor condition at this time. The child was followed for 1 year in the out patient clinic with no improvement of the pyelitis which he contracted shortly after the second hospital admission. The child did not return and further prognosis of the case is not known.

S. K., Case No. 141466, 7 day old white female entered the Doernbecher Hospital on October 9, 1944, one of twins, with only a dimple at the anus. The child had an opening between the vagina and the anus (Fig. 2). A repair of the imperforate anus was done; the rectovaginal fistula was dissected out and removed and the mucous membrane was sutured to the skin at the anal dimple forming an anal orifice. The rectal pouch was approximately 2½ centimeters from the anal dimple. The child made an excellent recovery and was discharged on October 30, 1944. Since this time the child has been asymptomatic with good sphincter control.

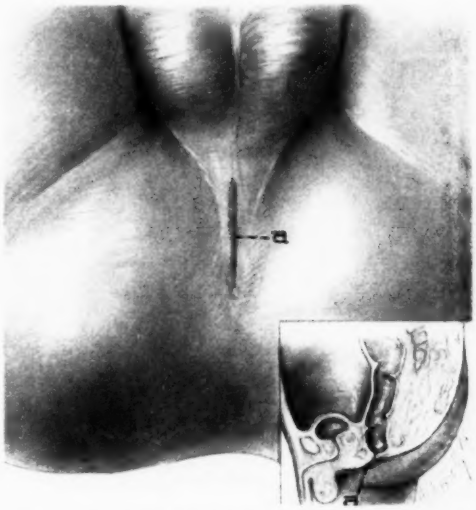

Fig. 1. Unopened channel running from the anal dimple to the base of the scrotum. This was filled with inspissated meconium.

L. H., Case No. 112704, 1 day old white male was brought in with an imperforate anus. X-ray films on admission showed the air column in the rectum to be within 1½ centimeters of the anal dimple (Fig. 5 and 5a). The child was taken to surgery where the rectal pouch was opened from a perineal incision. A large amount of meconium was expressed. The cutaneous margin of the rectal pouch was unable to be sutured completely to the anal opening and a rubber tube was inserted. This was kept dilated daily and thus a normal opening was established and the child was discharged and has remained asymptomatic.

B. M. C., Case No. 106001, 3 day old white female entered Doernbecher Hospital on January 17, 1945

Fig. 2. Drawing of the rectovaginal fistula, which was present in 7 cases of our series.

Fig. 3. a, Showing pneumoperitoneum in case of imperforate anus.

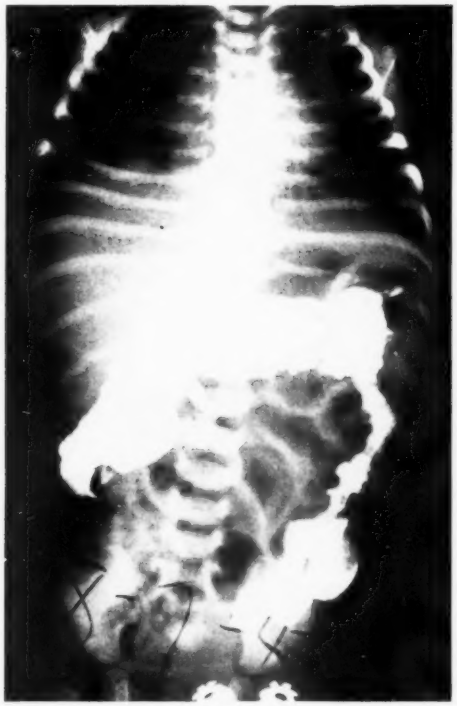

Fig. 3. b, Injection of colostomy with barium—no filling below the sigmoid.

with a rectovaginal fistula and absence of anus (Fig. 2). Distance from rectal pouch to the anal dimple is unknown. The child was not treated at this time for the imperforate anus and was discharged. The child also had atresia of the esophagus, incomplete.

D. A. F., Case No. 91607, 3 day old white male entered Doernbecher Hospital on September 19, 1938 with an imperforate anus. X-ray films revealed a gas bubble to be just skin thickness from the rectum (Fig. 5a). The child was taken to surgery where the skin overlying the anal dimple was opened and the rectum was opened. A large amount of meconium was released. The anus and rectum were dilated twice daily. The child made an uneventful recovery and was sent home. The mother was instructed to dilate the anus daily for 6 months. The child has had not complications since.

R. G., Case No. 123004. This child had an imperforate anus at birth on May 8, 1938. On May 9, 1938 a colostomy was performed. The child had apparently carried on a normal activity at that time until the admission on November 15, 1941, at which time x-ray films of the pelvis were taken after injection of lipiodol through a distal colostomy loop with an opaque marker pressed against the anus which was imperforate. The distal rectum was absent and there was a distance of 4 centimeters from the opaque marker to that portion of the rectum which was filled (Figs. 4 and 4a). At the operation an anterior posterior incision was made in the midline of the perineal floor, extending from the scrotum backward almost to the tip of the coccyx. The anal sphincter muscles were partially split in order to give adequate exposure, and it was necessary to bisect the perineal body in order to reach the rectal pouch. The latter was located about 3 to 4 centimeters above the anal dimple. The pouch was then carefully freed from adjacent tissues and structures. The rectal wall was then fixed to the subcutaneous tissue with interrupted cotton stitches after the pouch was freed sufficiently to allow it to be brought to the perineum without tension. The pouch was opened into and the lumen demonstrated by the presence of the rectal tube which had been placed in the colostomy before surgery. The lining of the pouch was then sutured to the skin of the perineum, leaving an opening which was sufficiently large to easily admit the big index finger. Then a side-to-side anastomosis of the two loops of colon was done. The abdomen was then closed in layers around the colostomy. In attempting to dissect the dense adhesions free from the colostomy the bladder was inadvertently opened into, but im-

Fig. 4. X-ray film with lipiodol injected into the distal colostomy loop showing end of bowel a great distance from perineum.

Fig. 4. a. Drawing of the defect shown in x-ray film in Figure 4.

mediately closed. After surgery a retention catheter was left in place. Colostomy was closed on April 1, 1942. After surgery child made an uneventful recovery. During the last 2 years he has had fair bowel movement with fair sphincter control. The anus has been dilated at intervals.

L. B., Case No. 146510, 2 day old white female, was admitted to the Doernbecher Hospital on July 7, 1945 with the chief complaint of imperforate anus. The patient vomited mucus 1 hour after birth and has vomited all offerings by mouth. Upon attempting a rectal, the nurse discovered the anus to be closed. No other congenital abnormalities were noticed. Anteroposterior and lateral x-ray films were taken (Figs. 5a and 5b), and showed air outlining the rectum which extends down to within about 1 centimeter of the dimple of the anus. In the lateral film the direction of the rectum is normal, the blind end extending posteriorly. The pouch is broad with smooth borders. Patient was taken to surgery at 3:00 p.m. on July 7, 1945. Under ether anesthesia the imperforate anus was repaired. The septum which was between the rectum and the anus was divided and the mucus membrane of the rectum was sutured to the mucus membrane just internal to the sphincter. Patient passed considerable gas and meconium and was returned to the ward in good condition. Patient was discharged July 15, 1945 asymptomatic. The anal outlet was to be dilated by home physician to keep the opening adequate. The patient has been asymptomatic since.

A. P., Case No. 140517, 16 month old white male entered the Doernbecher Hospital on August 11, 1944 for his first admission. He was treated at this time for chronic sinusitis and a kidney infection. He had had an operation for an imperforate anus at the age of 4 days (Fig. 5a). On the present examination the child has an extremely small stenotic anus which will not admit the tip of the little finger. The patient also had a megalocolon from obstruction from massing of feces in the colon. Cystograms and intravenous pyelograms disclosed two kidneys on the left side. One is normal and one showed a marked nephrosis and hydroureters. The child gave the impression of having renal rickets and renal dwarfism, with a low blood calcium of 7 milligrams per cent. On August 22, 1944 the child had a manual dilatation of the rectum and the large bowel was cleaned out. He was discharged August 23, 1944. On September 25, 1945 the child was readmitted to the hospital—dead on arrival. Autopsy revealed extensive bronchopneumonia; agenesia of the right kidney; double left pelvis and ureters with hydronephrosis and megaloureter; megalocolon; undescended left testis.

T. T., Case No. 140691, 4 month old white male entered the Doernbecher Hospital on August 21, 1945 with the chief complaint of constipation and vomiting. Patient was well until 4 days previous to admission when he became very irritable, did not have any bowel movements and vomited several times. The physical examination was essentially negative except for a distended abdomen which had visible peristalsis and tympany. The rectal sphincter was very tiny. It would not admit the finger. Otherwise, the physical was essentially negative. Hematology, tuberculin, and serology were negative. Barium enema revealed a large redundant sigmoid with anal stenosis (Figs. 6 and 6a). The child was given daily anal dilatations which resulted in relief

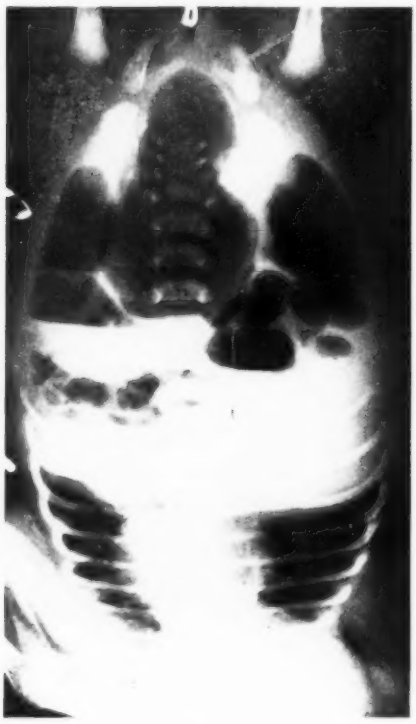

Fig. 5.

Fig. 5b.

Fig. 5. a, Showing Wangensteen and Rice method of determining where the rectal pouch ends, by taking antero-posterior and lateral x-ray films with baby upended and a metallic marker at the perineal dimple. b, Drawing of type of defect shown in Figure 5a of which type there were 6 cases in our series.

of distension and partial obstruction. Follow-up care showed no further bowel obstruction and after

Fig. 5a.

several months of anal dilatation, he had had no more symptoms.

L. W., Case No. 141451, 6 day old male infant entered Doernbecher Hospital on October 7, 1945 for relief of imperforate anus, also for a deformity of the right forearm and genitalia. Physical examination revealed an enlarged heart with soft, systolic murmur heard at the apex. Imperforate urethra, atresia of the anus, absence of the right radius and right first metacarpal. X-ray films were taken showing an area about 3 centimeters from the air filled rectum to the perineal dimple. Child was taken to surgery on October 8, 1945 where an attempt was made to bring the rectum down to the perineum. The rectum was not found but the bladder was exposed, opened, and the edges sutured to the anal opening. Due to the distance of 3 centimeters from the perineal dimple to the abdominal cavity, the bowel could not be brought down, so a left rectus incision was made into the peritoneal cavity. The sigmoid colon was exteriorized and a double-barrel colostomy was established. No external urethral opening could be found. The colostomy was opened and a small amount of meconium came out. The bladder was brought down because of possible contamination with colostomy, suprapubic drainage was contraindicated. The child did not respond well after surgery and expired.

P. A. R., Case No. 117417, 6 week old white female, entered Doernbecher Hospital on March 7, 1941 with a stenosis of the anal opening (Fig. 6a). The rectum was dilated and the dilatations were continued for several months after which the child remained asymptomatic.

M. F. H., Case No. 77635, 4 hour old white female entered Doernbecher Hospital on July 26, 1939 with an imperforate anus and a rectovaginal fistula since birth. A barium enema was given through the rectovaginal fistula showing a greatly dilated rectum. The rectum was found to be 3 centimeters from the anal dimple. A colostomy was done at this time. On June 10, 1940 a repair of the rectovaginal fistula was done. The fistulous tract was excised and the rectum was brought out to the anal dimple and the mucous membrane was sutured to the skin. Permanent colostomy was not made since the child had a fairly adequate anal opening with sphincter control. The child did not come in for follow-up care.

A. D. P., Case No. 95440, 1 day old child, was admitted to the Doernbecher Hospital on January 15, 1939 with the chief complaint of imperforate anus. He was a full term, well developed baby weighing 10 pounds. There was a small sinus tract which appeared to be filled with meconium extending out from the anal dimple. By pressure over this area meconium passed back into the rectum. On January 16, 1939 a small incision was made in this tract and a probe passed through it into the rectum. The tract was dilated gently with a hemostat. A large amount of meconium was expelled. This tract was dilated gently every day to keep the anal ring open. There was good sphincter tone present. It functioned fairly well until 1 year of age at which time the child was again admitted to the hospital complaining of abdominal pain and vomiting. At this time the child was well developed and well nourished. The anus was very small, partially admitting the tip of the little finger. The rectum was filled with fecal material. The child was taken to surgery at this time and the sphincter ani was dilated under ether anesthesia. A large amount of dry fecal material was removed. The child's rectum was dilated daily up to a No. 32 French catheter. Since this time the child has been fairly well.

R. E. K., Case No. 102290, 3½ month old white female, entered the Doernbecher Hospital on September 6, 1939 for surgical correction of an imperforate anus. The child has been having fairly regular bowel movements through a rectovaginal fistula (Fig. 2). The child has never vomited and seems to be in every other way a normal child. Physical examination revealed a well nourished, well developed girl. No anus is present, but a small dimple can be seen on the perineum. Urinalysis revealed a three plus pus. Hematology showed an 86 per cent hemoglobin and 17,000 white blood count. A new rectal outlet was created to correct the imperforate anus. The rectal pouch was 3 centimeters from the perineal dimple. The rectovaginal fistula was not closed at this time. The child was discharged asymptomatic.

Fig. 6.

Fig. 6a.

Fig. 6. X-ray film showing anal stenosis and dilated sigmoid. a, Drawing of type of lesion shown in Figure 6. (Two of our series were of this type).

The early recognition of these malformations, especially those with complete obstruction, is important. Inspection at the time of the delivery will reveal almost all the abnormalities, except the defect such as in Figure 7. In this type of case the external opening ap-

Fig. 7. Drawing showing pathology in patient who appeared to have normal rectal opening.

pears normal and the rectal temperature can be taken, but no meconium passes.

The operative details in these cases are as follows: The child is placed in the prone position, with the hips elevated, and an incision is made in the midline in the region of the anal dimple in the anterior-posterior direction. The external sphincter is thus divided in the midline and its function not destroyed. The external sphincter is usually present in these cases, inasmuch as its mesenchymal origin, embryologically, is different from that of the rectum itself. Thus anal control is usually good. When the bowel is any distance from the perineum, it is freed by dissection sufficiently to bring it down and suture it to the skin between the lateral halves of the sphincter muscle, with closure of the skin anteriorly and posteriorly to the rectum.

In the cases of rectovaginal fistula, it is easy to make the mistake of not bringing the rectum far enough posteriorly. In these cases the area of the rectum, where the fistula exists, is best brought to the outside, or otherwise, the fistula may recur. In all of these cases tension must not be present in suturing.

The cases of rectovesical fistula and rectourethral fistula must not be repaired until the child has attained some growth.

The postoperative care of the rectal opening depends upon careful, gentle dilatation with a bivalve nasal type speculum. This should be kept up at occasional intervals until the anus admits the examining finger. Some of the cases that require colostomy may later have the bowel brought to the perineum and the colostomy closed. Our case, No. 123004, was so treated. A rectal tube was placed in the distal colostomy opening and helped identify the lower end of the bowel at the time of the perineal dissection. After closure of the colostomy, the child had good bowel control.

SUMMARY

1. Twenty cases of malformation of the anus and rectum have been reviewed.

2. Important points in their recognition, study, and treatment are discussed.

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THE MANAGEMENT OF OSTEOMYELITIS SECONDARY TO WAR WOUNDS

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THE occurrence of long existing suppurating wounds associated with compound fractures has been one of the most important problems encountered by the military orthopedic surgeon. The circumstances under which soldiers receive wounds, that is, with dirty clothing in place, fragments of land mines carrying infected soil into wounds, shell bursts which plow up the ground and then reach the limb, and the delay in getting surgical care, all go to make a great number of infected fractures during a war. In spite of the hazards of military wounds, however, it has been surprising to see the number of limbs which healed quickly when early medical care was given. The majority of the compound fractures treated by the temporary open wound method healed in the same period that a closed fracture would unite in civil life.

TYPES OF CASES

The usual compound fracture patient who was received in a general hospital from overseas had a well fitting cast with the fracture in good position and alignment. If there was a foul odor to the cast, the plaster was changed soon after admission to the hospital because every man wanted a furlough or leave as soon as possible. Usually the wounds at that time were mere granulating areas which needed silver nitrate cauterization, a skin graft, or sometimes the patient had already undergone a secondary closure. In other cases bone was exposed in the wound and frequently loose sequestra could be lifted out. This type of patient showed no sign of sepsis and his general health was good. His blood count, hemoglobin, and hematocrit readings were normal. His state of nutrition was good, and he needed very little treatment other than cast immobilization until sufficient healing of the bone had occurred. Practically every one of these patients was started on some therapeutic exercise to the injured limb even while in the cast, moving the neighboring joints or muscles underneath the cast. At times, in other cases, there was so much drainage from unhealthy soft tissue wounds that the surrounding skin was in bad condition from the presence of the secretions. These later suppurating wounds were treated in whirlpool baths for a period if the bones were in a condition to allow a minimum of immobilization. These warm water baths helped to clean up the wounds and skin very quickly.

Another group of patients had unhealed or healing fractures with suppurating wounds with a definite bone infection as shown by x-ray examination. In some sequestra, shell fragments, and débris were present; in others good drainage was lacking. The majority of these patients showed very little, if any, systemic changes due to the bone infection. Their nutritional state was excellent and their blood count, hemoglobin, and blood volume were normal. These patients usually needed surgical treatment and an attempt was made to eliminate the infected areas in from 3 to 4 months following injury. In some instances the removal of a sequestrum or foreign body resulted in permanent healing of the wound; in others dead bone was found attached to callus because surgery had been inadequate to insure continuous drainage of small or large spicules of bone and dead tissue.

Another group of patients who had had severely traumatized extremities with long existing suppurating wounds, showed marked evidence of the systemic effects of chronic sepsis. This type of patient was more difficult to treat, and it took a much longer time for healing to occur. These patients had very little immunity to their infection and were in an extensively depleted state.

The septic and depleted patient was in no condition to withstand surgical drainage, removal of foreign bodies and dead bone, or

Fig. 1. a and b. Postoperative osteomyelitic defect of femur lined with skin 3 months following surgery; range of motion shown.

Fig. 2. a, left, Postoperative osteomyelitic defect in femur covered with skin. b, Knee region of femur after excision of skin; the bone defect had been filled with adjacent muscle and the skin edges had been approximated.

local therapy. He was treated medically rather than surgically to prepare him for the shock of definitive surgery. The usual patient with a severely infected compound fracture had a loss of appetite, an anemia, a great loss of weight, and general debility. There was extreme wasting of soft tissues, muscles, and fat as well as atrophy of bone in these patients due to prolonged sepsis and impaired nutrition.

Many of these debilitated patients had traveled thousands of miles and had had to undergo the rigors of litter travel over mountains and through jungles. In traveling there had been many changes of diet and lack of comforts which are so essential to a sick patient. Frequently these patients were upset emotionally and did not want many things done for them. They preferred to stay in a private room and rebelled against being turned over in bed in order to treat their bed sores and be cleansed. It was found most satisfactory to treat these men in wards where their companions could cheer them up or scold them when they became abusive to nurses and other personnel. In several days' time the emotional upset disappeared when they learned that so many things were being done for them, and that there were others around them who were a little worse off.

TREATMENT

A general physical examination was made as soon as possible after the patients entered the hospital, and laboratory work was done to determine the presence of any deficiencies in blood and diet. At times it was necessary to use 2500 to 3000 cubic centimeters of whole blood to restore a red count to near normal. Frequently suspended red blood cells were used instead of whole blood. An attempt was made to control sepsis with penicillin and sulfadiazine. In the severely ill, penicillin was started before laboratory analyses were finished, usually giving from 200,000 to 500,000 units by intravenous drip during the first 24 hours. This was followed by penicillin intramuscularly in 25,000 unit doses every 3 hours for as long as it was needed. Sulfadiazine was started simultaneously and was tolerated well by most patients. A few patients were found to be sensitive to the early penicillin products and with any reaction, it was discontinued. At times it was judged that the infecting organisms were penicillin resistant, and sulfadiazine usually worked in a dramatic manner

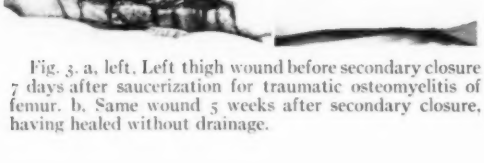

Fig. 3. a, left, Left thigh wound before secondary closure 7 days after saucerization for traumatic osteomyelitis of femur. b, Same wound 5 weeks after secondary closure, having healed without drainage.

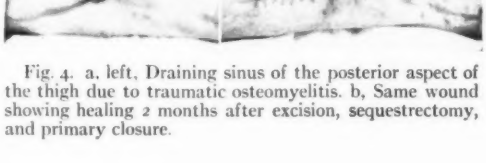

Fig. 4. a, left, Draining sinus of the posterior aspect of the thigh due to traumatic osteomyelitis. b, Same wound showing healing 2 months after excision, sequestrectomy, and primary closure.

in these cases. As a result of these experiences, a combination of penicillin and sulfadiazine was used because infecting organisms can become resistant to either one or possibly both drugs.

Frequently in the depleted patients, a protein deficient state was found with a loss of weight and a lack of appetite. It has been shown that in protein deficient diets in the presence of infection the ability to form specific antibodies is markedly impaired. With these implications in mind by the use of whole blood, serum, amino acids, and penicillin and other medications, the patients' appetites were increased, and usually the diet alone could then be depended upon to furnish sufficient proteins. A high caloric, high protein diet was used, and if necessary amino acids were provided by mouth and intravenously. A few of the patients were returned showing extreme signs of avitaminosis, and so a generous vitamin replacement was attempted.

During the early war years, the majority of infected fractures were treated surgically by the Orr method or a modification of it. After sequestrectomy and saucerization, the wounds were packed with vaseline gauze followed by the application of a plaster cast. Infrequent dressings were done, and the wounds were allowed to granulate up from the bottom. This was a very slow process, and with extensive soft tissue wounds and great bone loss, other methods were sought for. With the advent of penicillin, the wounds were packed with gauze impregnated with penicillin solution. Frequently a rubber tube was inserted in the gauze, and penicillin irrigations resorted to. This solution greatly deodorized the secretions, lessened the drainage of pus, and healthy granulations seemed to form quickly. A change of dressings was necessary about three times a week, and frequent cast changes due to softening of the plaster were the rule when the irrigations were used. It was observed that a considerable number of patients receiving local penicillin therapy developed an added pyocyaneus infection which did not seem to interfere with the end-result.

The treatment of compound fractures with osteomyelitis went through numerous changes in 1944 and the spring of 1945 due to experiences that were passed on from one military hospital to another, and with the exchange of ideas by the consultants of the different branches of medical organizations which were relayed to military hospitals. The number of osteomyelitis cases were so numerous that the surgeons' time in general hospitals was almost entirely taken up with dressings and changes of casts. A plan was devised that all early infected fractures were to be treated with an incision and drainage if necessary, packing, a cast or traction immobilization until a period of time had elapsed when the infectious process had reached a chronic state. At that time, the bone infection was usually localized, the bacteria present were not too active, and the patient had received enough preparation to undergo extensive surgery which attempted to produce a healed wound in a short period of time by use of a skin graft, a delayed closure, or a primary closure. Lieutenant Colonel Robert Kelly at Ashford General Hospital had re-evaluated the possibilities of skin grafting in osteomyelitis, and when he reported his successes the method was instituted at Billings General Hospital. Past experience with primary and secondary closures in civilian practice with potentially infected fractures and with osteomyelitis led to the use of these methods when indicated in war fractures.

Between 3 and 4 months following the initial accident, surgery was planned for the patient who had osteomyelitis. In preparation for the operation, an attempt was made to bring a patient's blood count and hemoglobin to very near normal before any surgery was attempted. Every patient was made ready for a transfusion on the day of surgery in case it was needed. Wound cultures were made before surgery to find out which organisms were present. After cultures were made in a large number of wounds before and during surgery, it was concluded that the bacterial flora of the wounds were not of great importance in the majority of cases as long as penicillin and sulfadiazine were used. On several occasions the two drugs were not given preoperatively, and after surgery, even on the same day, high temperatures and a fast pulse resulted which subsided with medication within a few days. As a result of these experiences, 150,000 units

of penicillin together with sulfadiazine were started 4 days before surgery and were continued after surgery for 4 to 5 days and little, if any, reaction followed.

After 4 to 7 days' preparation, a compound fracture with osteomyelitis was usually ready for some type of surgery. At operation a pneumatic tourniquet was used when possible, and it has proved to be a very valuable adjunct to this type of surgery of the arm, forearm, and below the upper one-third of the femur. The blood was expressed from the extremity with elastic bandages or by elevation previous to the application of the tourniquet. The advantages of a dry field for this type of surgery are that one could see the diseased areas of bone more clearly and furthermore the amount of blood lost was kept at a minimum.

At the time of surgery the draining sinuses were opened widely down to the infected fracture. All loose and dead fragments of bone, metallic fragments, and débris were removed. A generous saucerization of the bone was done. The scarred and avascular tissues were excised from the wound. Then the wound was flushed with normal saline to remove any small bone and soft tissue débris. Then moistened muslin or nylon strips which were close meshed were used to line the depths and sides of the wound, and mechanics' waste or gauze was packed on top of the muslin with gentle firm pressure. All patients were immobilized in plaster or traction. Postoperative oozing was controlled by elevation of the part, and if the pack had been placed correctly, there was usually a minimum of bleeding. In extensive saucerizations, the patient frequently needed a transfusion during or after surgery, depending on the amount of blood lost. From 200,000 to 500,000 units of penicillin were given in 2000 cubic centimeters of saline in the first 24 hours after operation. After that period the drug was given intramuscularly at 3 hour intervals in 25,000 unit doses during the day. Sulfadiazine was started after surgery as soon as the patient could tolerate it by mouth. As soon as possible, these patients were placed on the high protein, high caloric, and high vitamin diets.

Several days following surgery a blood count, hemoglobin, and other laboratory analyses were made to determine the patient's reaction to the surgery. Transfusions were given as often as was necessary to make the red blood count and hemoglobin of these patients approach the normal in order to build up their resistance and immunity to infections.

Following saucerization surgery, the wounds were treated by one of several methods. The procedure that was used most extensively was the application of a split thickness skin graft. On the sixth or seventh day following the initial surgery, the cast was removed, and the wound packing was taken out. Cultures were made from the wounds for study. At this time, there were usually fine healthy granulations present with a clean appearance of all the tissues. If, however, the wound appeared dirty with some necrotic tissue showing, and definite areas of pus present, then further surgical and possible chemical treatment of the wound was necessary to make it receptive for a skin covering. Otherwise on the following day, the packing was removed, and a split thickness skin graft was taken with a Padgett hood dermatome and applied to the depths and sides of the wound. The grafts measured from .014 to .018 inch, the thinner grafts being used in the least favorable recipient sites. Before applying the skin, the saucerized defect was prepared by freshening the surface of the wound with a scalpel or gauze, removing any necrotic tissue, slough, or blood clot. Then the defect was irrigated thoroughly with saline and packed with warm moist gauze until the skin was applied. The skin was tailored to fit the defect without tension, and the graft was sutured to the wound edges with interrupted silk stitches. The grafts were perforated in several areas to allow the escape of excess secretions. A layer of boric acid ointment gauze was applied over the skin, and gauze packing or mechanics' waste was inserted in the defect on top of the skin. Dry dressings were placed on top of the packing, and an ace bandage was used to maintain an even firm pressure in the wound. Plaster splints were applied to the extremity, and the limb was elevated on returning to bed. Penicillin and sulfadiazine which were begun before the saucerization were continued after skin grafting for 5 to 7 days. At the end of a

week, the wound packing and boric ointment gauze were removed, and the graft was exposed to the air. A heat lamp was applied two or three times a day for 15 to 20 minutes if the graft was moist.

Another type of wound treatment following saucerizations that proved to be a very valuable procedure was the method of secondary closure. When the wound edges were not separated widely, and there had been only a minimum of soft tissue loss, these conditions seemed to be ideal for a delayed closure. If one expected to use this method following saucerization, the wound was packed similarly to that mentioned before the skin grafting procedure. Seven to 10 days later, the packing was removed, and the wound inspected. If it was clean, then a moist pack was inserted, and the patient was made ready for surgery on the following day. At surgery, the skin edges were excised, and the soft tissues were loosened up enough to approximate the skin and subcutaneous tissues. After a thorough cleansing of the wound with saline, the skin and subcutaneous tissues were closed with through-and-through stitches, avoiding if possible the use of buried sutures. If any dead space remained, a soft rubber drain was inserted for several days. In case the wound looked grossly infected and dirty, treatment with irrigations and penicillin packs was carried out for a time before closure was attempted.

Another method of delayed closure used successfully in superficial saucerizations was the shifting of a lateral flap of skin and subcutaneous tissue over the wound and the suturing of the edges. The bare wound left after the flap was moved was covered with a split thickness skin graft where needed.

Treatment of osteomyelitis secondary to war wounds by primary closure was carried out in a number of instances at the time of saucerization. Frequently when there were foreign bodies in infected bone, infections of the ilium and other pelvic bones, and cases of insidious drainage with sequestra present, primary closure proved to be an ideal treatment. At times a flap of skin and subcutaneous tissue was shifted over the saucerized area, as mentioned under secondary closure, and a split thickness graft placed over the denuded area.

ANALYSIS OF RESULTS

An analysis of the results of wound treatment following saucerization surgery by skin grafting, secondary closure, and primary closure has been made. No case was considered successful unless the wound had been healed for at least 3 months. The results with the skin grafting type of treatment have been most satisfactory. A recent survey of 264 cases revealed a complete healing of 25 per cent of the wounds in 30 days. At the end of 60 days, another 50 per cent of the cases had healed, leaving 25 per cent unhealed. Of this latter group only 6 per cent were complete failures. The remaining patients needed a partial resaucerization and skin graft. The failures of this method have been judged to be due to a poor blood supply to the tissues under the graft, a lack of maintenance of firm even pressure by the dressing after skin graft surgery, and lastly due to infected tissues under the graft and incomplete saucerization surgery. The skin graft method has been very popular with the patients in military hospitals because it created a closed wound from a dirty infected one in a short period, eliminating the dressings, odors, and inconveniences of some other methods. Since the soft tissue wounds healed quickly with this method, the bones likewise healed rapidly when they received a skin covering. However this treatment did not eliminate altogether the need for further surgery in all the cases. Many deep and wide wounds having a thin skin covering needed good skin flaps with fatty subcutaneous tissues when further bone surgery was planned to keep the wounds from breaking down with usage, and in others for cosmetic reasons. These patients were usually given a trial of 3 months hard usage on the extremities if the bones had healed. At the end of that period if the skin wounds had not broken down, then the patient did not need to undergo further surgery unless he wanted it for cosmetic reasons.

The results of delayed closure were very encouraging, the wounds showing some drainage in 9 instances out of 42 cases which were

followed. A number of these wounds closed spontaneously after a few weeks' drainage. The secondary closures in which a drain was inserted at the time of surgery because of a dead space, usually closed spontaneously in the majority of instances within 7 to 10 days following removal of the drain. The failures in this group of cases were attributed to incomplete surgery and the leaving of a dead space where tissue fluids collected.

Primary closure was used in 46 patients, and wound drainage following surgery occurred in 10 instances. This low percentage of reinfection could probably be accounted for by the proper selection of cases for the use of an immediate closure.

SUMMARY AND CONCLUSIONS

The management of osteomyelitis secondary to war wounds has not been a problem of curative surgery alone. At times intensive constitutional treatment was necessary to alleviate the attendant anemia, hypoproteinemia, and disturbed fluid balance in the septic and depleted patient.

Frequently the patient was in a low mental state.

Five methods of wound treatment following sequestrectomy and saucerization were used. This study has revealed that delayed closure, primary closure, and skin grafting were very useful procedures in creating an early closed wound from an open infected one.

THE SURGICAL TREATMENT OF GANGRENE IN TRENCH FOOT

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THOUGH gangrene in trench foot has similarities to gangrene in other vascular disorders, it presents certain problems which are peculiar to this condition. Distinguishing features are the high incidence of infection, the occurrence of either superficial or deep gangrene of limited or considerable extent, the lack of pain due to the gangrene itself or the resulting ulceration, the common association of intense vasospasm, and the absence of any extensive arterial obliteration in the foot proximal to the area of gangrene.

Trench foot gangrene differs from the gangrene of thromboangiitis obliterans, arteriosclerosis, and other obliterative diseases chiefly because of the general absence in trench foot of the reduction in the circulation of the foot from obliterative arterial changes so regularly present in these diseases. Conversely, whereas relatively normal circulation rarely prevails in the obliterative disorders upon elimination of vasoconstrictor impulses, relatively normal circulation does generally prevail in the case of trench foot. Trench foot gangrene further differs from the disorders named in the general lack of any severe rest pain even when open ulcers are present. Initially there may be very distressing rest pain in patients who have trench foot, whether gangrene is present or not, but after an interval of some weeks or months the majority of patients have little or no pain at rest. Though infection sometimes complicates gangrene in the obliterative diseases, it is much more commonly present in trench foot with deep gangrene. Skin defects can rarely be covered by grafts in the former but can often be repaired in this manner in trench foot.

In Raynaud's disease and like disorders the ulcerations and gangrene are generally superficial and limited in extent. In trench foot the gangrene may be superficial or deep, limited or extensive. The gangrene of trench foot is closely allied to that which follows frostbite and immersion foot. All of these disorders are alike in that obliterative arterial changes are largely limited to the areas of gangrene and perhaps to areas immediately proximal to these. Patients with frostbite and disorders resembling Raynaud's disease tend to have few symptoms associated with gangrene other than cold sensitivity and hyperhidrosis which are very common in the former and the rule in the latter. In trench foot and in immersion foot, on the other hand, there are generally associated symptoms consequent to damage of nerves and muscles in the foot proximal to the area of gangrene. Areas of hypesthesia or hyperesthesia, atrophy of muscle, and contractures are relatively common in trench foot, and almost all patients have pain on weight bearing. These symptoms are prevalent in trench foot without gangrene and are not due to postural difficulties resulting from the ischemic loss of tissue. Hyperhidrosis, coldness, and cyanosis are commonly present.

It is the purpose of this communication to discuss certain problems which have arisen in the care of patients with gangrene from trench foot and to describe the manner in which they have been handled.

THE PROBLEM OF INFECTION

Infection was very commonly associated with the gangrene of trench foot. Infection was often minimal in instances of superficial gangrene but presented a serious problem in cases with deep gangrene, almost all of which had extensive infection. The circumstances in which trench foot is incurred all favor the introduction of infection. In the first place, the hygiene of the feet is necessarily often neglected under conditions of combat. At the time of exposure the patient has generally been unable to change his wet shoes and socks

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for a period of days or weeks. In addition to the tendency for skin maceration and bleb formation which appears to be the direct result of ischemia resulting from the exposure, the continual wetness of the feet and the edema further favor maceration of the skin. The blebs, skin desquamation, and loss of nails, which occur so commonly, serve as portals of entry for pathogenic organisms. Not infrequently the blebs on the digits are undergoing gangrenous changes.

When the patients are first seen as they are returned to the Zone of the Interior the gangrenous parts often are partially separated at the line of demarcation and this area is generally bathed in foul smelling pus. Sometimes there is evidence of extensive infection throughout the gangrenous portions. Not infrequently where the gangrene appears to be "dry," one finds on removal of this tissue through the line of demarcation that the gangrenous part is simply covering a pool of pus. The infection is invariably a mixed one and very commonly penicillin and sulfonamide-resistant Bacillus proteus and Bacillus pyocyaneus are present in addition to susceptible organisms.

Most of the patients were treated either with sulfadiazine or with penicillin. All of them were treated with sterile warm saline compresses. The gangrenous parts were excised or amputated through the line of demarcation. After this procedure was carried out there was a marked improvement in the infection. In no instance was there spread of infection to adjacent soft tissues. Osteomyelitis in the proximal stump, however, was often present and not infrequently required sequestrectomy, revision of stumps or other measures. The presence of infection handicapped treatment by precluding in most instances the primary closure of amputation stumps. Although the infection cleared grossly under treatment, it persisted in sufficient degree to offer some handicap to the success of split thickness and other skin grafts.

Of the measures instituted in order to control infection, it is felt that removal of the gangrenous parts and the use of warm sterile saline compresses were most efficacious. Not infrequently it was necessary to protect the intact skin with some ointment such as zinc oxide in order to prevent maceration during the period compresses were in use. This tendency to skin maceration seemed to have been greater than in normal limbs. It may have been due in part to the fact that large areas of skin were often only recently epithelized following extensive desquamation. It may have been due in part to the excessive hyperhidrosis which many patients had. With regard to sulfadiazine or penicillin it is felt that these drugs may have had some effect in preventing spreading of infection. If they had any beneficial effect upon the local infection itself this was not apparent. Use of aqueous mercurochrome locally proved more successful in clearing Bacillus pyocyaneus infection than dilute acetic acid. Unfortunately streptomycin was not available. From my small later experience with this drug in other infections in gangrenous stumps, it is believed that it might have been very useful.

A number of instances of apparently "dry" superficial gangrene have been seen in which there was present under the crust an active infection which led to osteomyelitis. In such cases amputation was often necessary. Because of this occurrence, it is my opinion that when areas of superficial gangrene fail to separate promptly they should be compressed in an effort to hasten separation of the gangrenous tissue, and epithelization.

THE PROBLEM OF VASOCONSTRICTION

Elsewhere (2) the problem of vasoconstriction in trench foot with gangrene has been discussed and the utility of lumbar sympathetic ganglionectomy in correcting this disorder has been described. It is sufficient to say that the majority of patients with deep gangrene presented evidence of rather marked vasoconstriction. The feet were frequently cold, cyanotic, and sweated profusely. In some cases the occurrence of vasoconstriction was masked by the infection and the local heat associated with the inflammatory reaction. In such cases cooling of the feet was observed as the infection cleared. In a few patients the feet were not only warm but had almost complete absence of sweating. Such cases were relatively few.

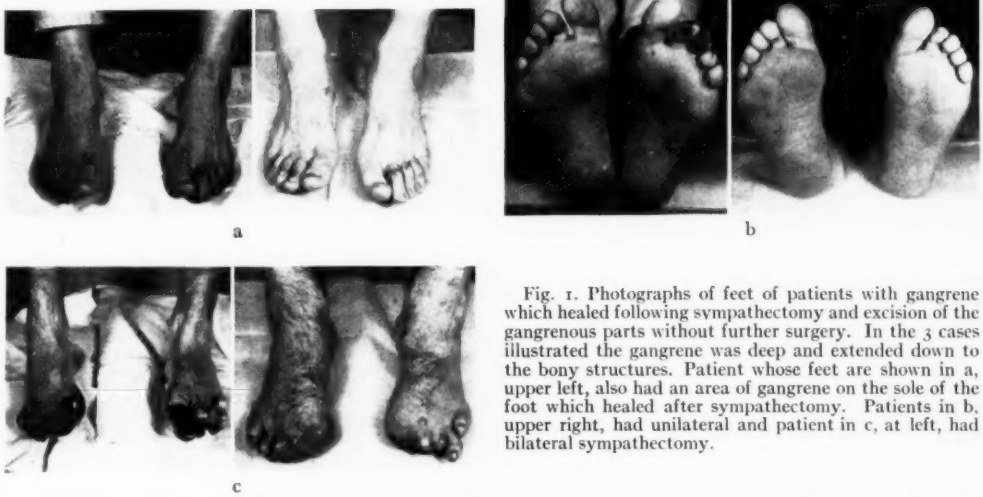


Fig. 1. Photographs of feet of patients with gangrene which healed following sympathectomy and excision of the gangrenous parts without further surgery. In the 3 cases illustrated the gangrene was deep and extended down to the bony structures. Patient whose feet are shown in a, upper left, also had an area of gangrene on the sole of the foot which healed after sympathectomy. Patients in b, upper right, had unilateral and patient in c, at left, had bilateral sympathectomy.

Although eventual healing can generally be obtained without sympathectomy, it is felt that this procedure has been most useful in bringing about prompt healing and in limiting the amount of tissue loss (Figs. 1 to 5). Thirty-eight lumbar sympathectomies were performed in 30 patients with deep gangrene. Satisfactory and fairly prompt healing occurred in all. Where small split grafts were attempted there was often difficulty in securing takes, but tube transfer grafts were as successfully transferred as to normal limbs. It was often striking how rapidly epithelization took place following sympathectomy. The contrast of this rapid epithelization to the former slow healing was especially evident in those cases in which sympathectomy had been performed in the presence of marked vasospasm. After operation the feet were warm, of good color, dry. The dryness was readily controlled with a daily application of lanolin.

In 17 patients with trench foot following unilateral sympathectomy, skin temperatures of the toes or stumps averaged 25.8 degrees C,

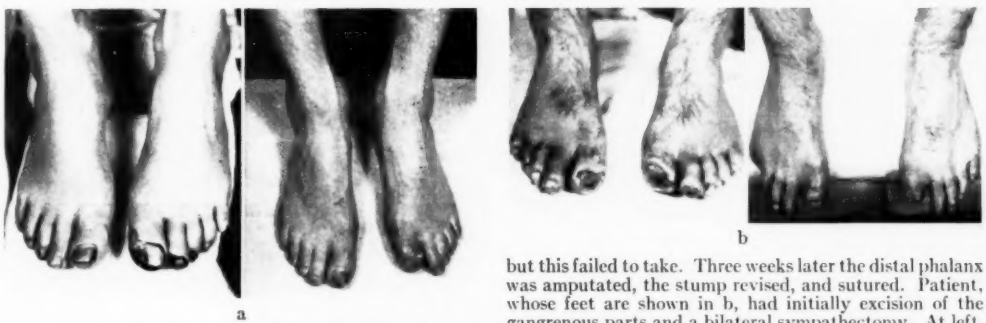


Fig. 2. Photographs of feet with gangrene, showing healing after sympathectomy and revision of stumps. A unilateral sympathectomy was done in patient in a, bilateral in patient in b. The gangrenous part was excised in patient a at the time of sympathectomy. Three and one-half weeks later a split graft was applied to the ulcer but this failed to take. Three weeks later the distal phalanx was amputated, the stump revised, and sutured. Patient, whose feet are shown in b, had initially excision of the gangrenous parts and a bilateral sympathectomy. At left, b, is illustrated the condition following this procedure. This patient demonstrates the difficulty resulting from infection. A split graft applied to the left great toe failed to heal. Both great toes required revision because of osteomyelitis and the right 5th toe was amputated because of osteomyelitis.

Fig. 3. Photographs of 4 patients with gangrene in which split thickness grafts were of considerable aid in obtaining a good healing with minimal loss of tissue. Unilateral sympathectomy was done in patients shown in a, b, c, and bilateral in patient in d. Split thickness grafts were utilized in covering the stumps of the 1st, 3rd, and 4th toes in a, the ulcer over the end of the metatarsals in b, the defect along the dorsomesial aspect of the toe in c, and the ulcers over the stumps of both 1st toes in d. A good functional result was obtained in all cases.

in the untreated limb and 33.2 degrees C, in the sympathectomized limb. Oscillometry at the ankle averaged 2.6 on the untreated side and 4.6 on the side operated upon. In general, the dorsal pedal and posterior tibial pulses were present and full, and there was no evidence to suggest any extensive obliterative change in the arteries of the foot. It is very

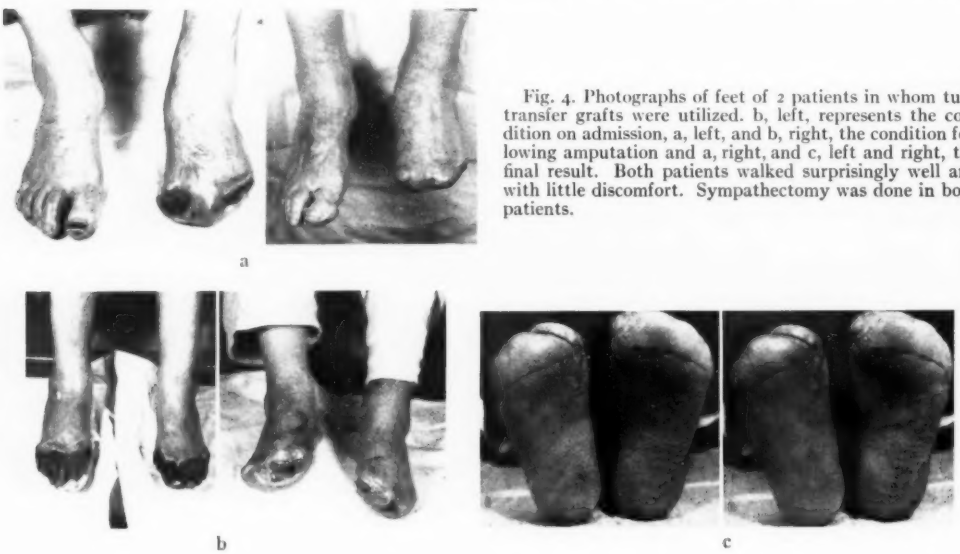
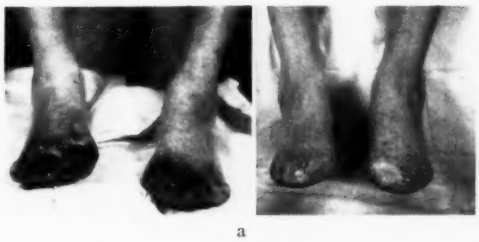
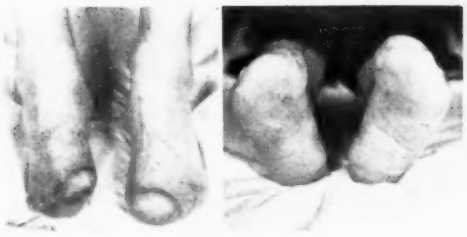


Fig. 4. Photographs of feet of 2 patients in whom tube transfer grafts were utilized. b, left, represents the condition on admission, a, left, and b, right, the condition following amputation and a, right, and c, left and right, the final result. Both patients walked surprisingly well and with little discomfort. Sympathectomy was done in both patients.



a

b



c

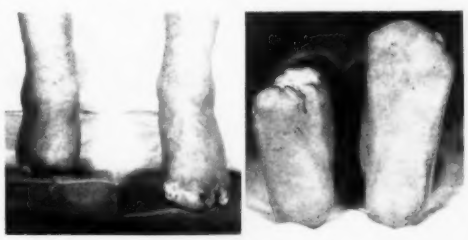
Fig. 5. Photographs of feet in which tube transfer grafts were utilized. a, left, represents the condition on admission and a, right, the final result. In this case both 4th and 5th toes were preserved but were subsequently amputated because of stiffness and discomfort. b, left and right, shows the condition following amputation in another case. The heads of the metatarsals are exposed. c, left and right, shows the final result after transfer of full thickness skin to both feet by means of a tube graft. Both patients had bilateral lumbar sympathectomy. A good functional result was obtained in both cases.

probably true that there may be thrombosis of the digital artery or small branches in the stumps adjacent to the line of demarcation.

THE PROBLEM OF AMPUTATION

Because of the prevalence of marked infection, closed amputations were rarely possible. Generally the gangrenous plaques and the gangrenous digits were amputated through the line of demarcation shortly after admission. If sympathectomy was performed, amputation was carried out at this time. Protruding stumps of bone were often left because the infection made it inadvisable to carry out a complete revision. Subsequently the stumps were revised, rongeuring away the protruding

a



b

c

Fig. 6. Photograph of patients who had extensive gangrene. In patient a, both feet were entirely gangrenous, and leg amputation was necessary. Patient in b had undergone prior to admission an amputation which was partially tarsal-metatarsal and partially through the proximal metatarsal area. The stump was painful and entirely unsatisfactory. He was transferred to an amputation center for a Syme's revision. c, Shows the end-result in a patient who had lost all toes and in whom healing occurred after sympathectomy. Because of the thin adherent skin over the stump, this was revised by sacrificing most of the head of the 1st and 2nd metatarsals. Though the stump was satisfactory it was felt that a more useful stump would have been obtained had a tube transfer graft been used instead of reamputation.

a b c

Fig. 7. Photographs showing the tube used in transferring skin, a, and the method of mobilization, b, and c.

phalanges. In many instances disarticulation was performed. No difficulty was encountered from disarticulation, and osteomyelitis in the stump was less common following this procedure than following amputation through phalanges. Every effort was made to avoid traumatizing the stump at operation and all the tissue possible was conserved. I feel that this policy of conservatism gave good results.

The extent of gangrene varied. In some patients a single toe was gangrenous and in others gangrene involved all the toes. In some the gangrene was limited to the distal or the distal and mid phalanges. In others the toes were completely gangrenous. In 13 extremities the gangrene was sufficiently extensive so that following amputation the heads of metatarsals were left exposed and in 7 it was necessary to remove portions of the metatarsals. Frequently in such cases it was necessary to cover the defect with full thickness skin by transfer graft. Where only a portion of the heads of metatarsals had to be sacrificed, useful feet were obtained. Only in 2 cases was foot or leg amputation necessary. One was a patient who had gangrene of both feet (Fig. 6a). He was transferred to an amputation center for a leg amputation. Another patient had undergone an amputation, partially tarsal-metatarsal, partially through the proximal portion of the metatarsals (Fig. 6b). His stump was painful, unstable, and entirely unsatisfactory. He was transferred to an amputation center for a Symes revision.

THE PROBLEM OF SKIN GRAFTS AND PLASTIC REVISION

In most patients skin grafting was unnecessary (Fig. 1). Where amputation was carried out through the phalanges, epithelization generally occurred promptly. In most of them the new skin was good enough to withstand the trauma of walking without difficulty. In a few instances a thin skin was adherent to bone and in these cases revision with primary closure could be performed. When a large defect occurred, particularly in instances where the entire toe or toes had been lost, it was desirable to cover the defect with a split thickness graft to serve as a temporary dressing even should full thickness skin subsequently have to be transferred. In general, split thickness grafts had a high instance of failures. It was apparent that this difficulty resulted from infection rather than from poor circulation in the stump. Occasional split thickness grafts were entirely satisfactory in covering defects (Fig. 3).

In 5 cases it was necessary to utilize tube grafts (Figs. 4, 5, and 7). In all of these cases the metatarsal heads were exposed. Fortunately, the skin of the sole was generally intact so that the graft would largely be on a non-weight bearing surface. When the first patient was operated upon it was my plan to elevate a double pedicle graft or tube from the opposite leg, to place beneath it a split thickness graft, and subsequently to transfer it to the defect of the foot. I was surprised to find

at operation that sufficient atrophy had taken place to permit primary closure of the skin beneath the pedicle. Primary closure was done, and the pedicle was converted into a tube. Three weeks later the tube was divided at its lower end and sutured to the defect of the foot, the limbs being held in place with plaster of Paris. In the other 4 cases in which transfer grafts were necessary it was found possible to utilize the same procedure.

The technique involved was as follows: Two parallel incisions were made on the posteromesial aspect of the contralateral leg. The width and length of the pedicle were determined by the size of the ulcer to be covered. The anterior incision was placed just posterior to the saphenous vein, and care was taken to avoid injury to the saphenous nerve. The skin between the 2 incisions was elevated with the underlying subcutaneous fat. The pedicle was gently retracted and the margins of the skin were sufficiently reflected both anteriorly and posteriorly to permit closure without tension. The pedicle was then converted into a tube by approximation of the skin edges with interrupted fine cotton sutures (Fig. 7). Between the second and third week after operation circulation in the tube was tested by application of a rubber tourniquet about the distal end of the tube. In all cases good circulation was maintained in the tube during a period of constriction with a rubber tourniquet. At the second operation the tube was divided at its lower end and the defect of the leg was closed by suture. The tube was then opened and sutured in place to the freshly mobilized skin edges about the area of the ulcer. The limbs were held in proper approximation so that the tube was not constricted and position was maintained with a plaster cast to both lower extremities (Fig. 7). In general the patients found this position comfortable. Three weeks later the cast was removed, the proximal end of the tube was divided and the free end of the graft was sutured in place.

In no instance was such a graft lost. In a single instance about 10 per cent of the distal end of the graft was lost but the small resulting ulcer readily healed and presented no difficulty. In one instance a small draining

Fig. 8. Photograph illustrating contractures of toes in trench foot, a, left. The patient had comfortable feet following amputation and revision of stumps, b.

sinus persisted in a portion of the suture line and considerably prolonged the patient's hospital stay. After efforts to obtain healing by saline compresses, curetting, and excision of the margins with a closure, a small sequestrum from the head of the metatarsal was finally discovered and healing occurred promptly after its removal.

When gangrene is limited to a portion of a toe and revision of the stump is necessary because of thin adherent skin or because of osteomyelitis, no harm results from the sacrificing of a small amount of tissue. When the metatarsal heads form the stump, however, it is my conviction that they should not be removed in order to permit bringing good skin over the stump. It is far better to cover such defects with full thickness transfer grafts. In Figure 6c is shown one patient in whom such a revision was carried out. Although the foot functions fairly well I have no doubt, in retrospect, that a much more comfortable and useful foot would have been obtained if a graft had been used and the metatarsal heads left undisturbed.

Stiffness and contractures of toes were not uncommonly seen in patients with trench foot without gangrene, and similar difficulties were sometimes encountered in patients who had sustained loss of tissue through gangrene. The stiffness of the toes could generally be satisfactorily cleared with physiotherapy and exercise. The commonest deformity resulted from an extensor contracture. Flexion contractures were fewer. Contracture was more common in cases of stumps of toes than where the entire toe was present. This condition was sometimes amenable to physiotherapy and the use of metatarsal bars. In a few instances in

which the contracture was severe and disabling, amputation was carried out. In such cases the deformity was generally so great that amputation was felt preferable to the conservative surgical methods (Fig. 8).

PROSTHESES

When all of the toes were removed a sponge rubber or cotton pad was placed in the distal end of the shoe to prevent the foot from sliding forward. In an occasional case where the great toe was present and the second or second and third toe had been amputated, a chamois covered sponge rubber pad which could be inserted between the toes and kept in place with a sock proved useful in preventing a hallux valgus deformity. In some patients with relaxation of the foot and discomfort on walking, resilient arch supports were helpful. In general the patients had little difficulty in standing or walking other than for slight or moderate discomfort in the metatarsal area. This pain on weight bearing was not peculiar to the patients who had undergone amputations, but occurred just as frequently in patients with trench foot who had had no gangrene at all. It was often helped by placing a second heel in front of the heel of the shoe or by the use of a metatarsal bar (1).

DISCUSSION AND CONCLUSIONS

Superficial gangrene in trench foot does not present a serious problem. Very often satisfactory healing takes place beneath the crust or following its separation. Occasionally superficial gangrene results in more serious difficulty because of the presence of underlying infection which may give rise to osteomyelitis. In such instances partial or complete amputation of toes may be necessary. Deep gangrene is a more serious difficulty. In the great majority of patients this gangrene is limited to portions of the toes. In a lesser number, entire toes are involved, and in some patients, gangrene is so extensive that the heads of metatarsals are left exposed following amputation.

Infection of a mixed character is present in the great majority of patients with deep gangrene. Such infection has been controlled satisfactorily with sulfadiazine or penicillin and with the local application of warm saline compresses following removal of gangrenous parts. Spreading of infection into adjacent soft parts did not occur. Occasionally osteomyelitis was present in the stumps. The infection tended to retard healing somewhat and to interfere with the success of split thickness grafts. It is felt that streptomycin would be of help in regard to infection, as organisms resistant to sulfonamides and penicillin are commonly present.

Vasoconstriction, sometimes intense, was present in the majority of patients. It is felt that lumbar sympathetic ganglionectomy is a useful adjunct in the treatment of deep gangrene of trench foot and that it results in more speedy healing and in conservation of tissue. In case skin defects have resulted from the loss of parts, epithelization has often occurred rapidly and in many instances the resulting new skin has been sufficiently good to withstand the trauma of walking. When the defects are large, occasionally satisfactory outcome is obtained by permitting epithelization from the margins.

In general it is advisable to cover such areas with a split thickness or full thickness graft. If the ends of metatarsals are exposed, a full thickness covering of skin is generally necessary. This covering is best applied by means of a transfer graft from the opposite leg. The most suitable means of carrying out this skin graft has been found to be a tube transfer graft. Because of the atrophy present it was possible in the first stage operation to elevate the tube and to close the skin margins beneath it without tension. Should this step be impossible a double pedicle flap can be elevated and sutured back in position or converted into a tube after there is placed beneath it a split thickness graft. The stump is satisfactory for standing or walking if all the toes are removed or if parts of the metatarsal heads must be removed. If amputation must be carried out more proximally through the metatarsals, the stump is generally unsatisfactory.

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A STUDY OF THE ABSORPTION CHARACTERISTICS OF SURGICAL CATGUT

GOTFRED HAUGAARD, Cand. Polyt., LAWRENCE A. THOENNES, Ph.D., and MARVIN J. HALL, Ph.D.

SINCE the introduction of catgut as a surgical suture material by Lister the problem of its absorption characteristics has been of vital interest to the medical profession. Numerous papers have been published and considerable time and energy have been expended in an effort to get a better understanding of the absorption process and of the best possible methods of controlling it so as to make available to the surgeons a product which is adequate to meet their needs. Some of this work has been carried out by investigators who have been handicapped by the need of obtaining their material through purchase on the open market and, consequently, have had no control over a number of factors which could have very definite bearings on their results. They have attempted to minimize this handicap by the multiplicity of their experiments and have succeeded in contributing much to the present knowledge concerning sutures.

We have been fortunate to be in a position in which we could obtain the raw material and process it ourselves so that all variables incident to the manufacturing process were controlled (chromicization, sterilization, et cetera). For this reason, and because we have occasion to introduce several new concepts, we believe that the results of our experiments will shed some new light upon the subject.

RELATIONSHIP OF TRYPTIC DIGESTION OF CHROMICIZED COLLAGEN TO SHRINKAGE TEMPERATURE AND THE CONTENT OF CHROMIUM

In vitro digestion of collagen. In order to correlate absorption of collagen implanted in the animal with proteolytic digestion, *in vitro* trypsin as well as pepsin have been used in the past. Kraissl and Meleney have used trypsin while Jenkins and Hrdina (5) used pepsin; however, no explanation has been presented for the choice of either one of the enzymes employed.

There is no doubt that the peptic digestion is influenced to some extent by the same factors as *in vivo* absorption and that valuable information can be and has been obtained in the past by this method. Jenkins and Hrdina arrived at a nearly linear relationship between "the duration of tensile strength in tissue" and "digestion time in acid pepsin." Although the applicability of pepsin to these problems has been clearly demonstrated by Jenkins and Hrdina, we feel that an enzyme more closely resembling the proteolytic enzymes of the tissue (cathepsin, et cetera) would be a better choice. In this connection, it can be pointed out that the *p*H optimum for pepsin is between 1 and 2, while the optimum of the proteolytic enzymes of the tissue is around 7. Furthermore, pepsin digests undenatured as well as denatured collagen quite readily but undenatured collagen is very slowly absorbed in animals. It has also been observed that digestion with pepsin seems to carry the collagen through a gelatinous state before breaking it down to polypeptides, which is not the case in animal absorption.

In trypsin we have a proteolytic enzyme which meets our requirements better. It has its *p*H optimum in the same region as cathepsin, undenatured collagen is not (or at least is very slowly) hydrolyzed, and no gelatinous intermediate product is found. Due to difficulties of preparation we have avoided the use of cathepsin itself; however, we feel that trypsin for our purpose is an adequate substitute.

The trypsin preparation used was a crude preparation from Central Scientific Company (Chicago). No attempt at purification was made, as all the digestion results were relative in nature.

In some of our earlier digestion experiments we have used the technique of determining the

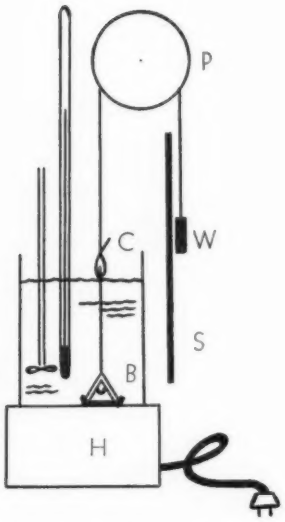

Fig. 1. Shrinkage temperature apparatus. *B*, base; *C*, battery clamp; *H*, heating element; *P*, pulley; *S*, screen; *W*, weight.

time it takes to break a strand immersed in the enzyme solution under mild tension. This technique, which was first introduced by Kraissl and Meleney, gives good, statistical results but is somewhat unreliable in a single experiment. This method was, therefore, replaced by determinations of the nitrogen content of the hydrolysates expressed as percentages of the initial collagen nitrogen present.

The shrinkage temperature. A collagen suture behaves in a remarkable manner when it is immersed in water and the temperature of the water gradually raised. At a rather definite temperature it contracts in the direction of the fiber axis and becomes elastic like rubber. This transformation temperature, or shrinkage temperature, can be measured nearly as accurately as a melting point of an organic compound. That a change in the configuration of the molecule has taken place can be clearly observed by x-ray diffraction and also deduced from the fact that collagen, which prior to the heating was practically indigestible by trypsin, now becomes readily digestible.

The shrinkage of collagen is without doubt closely related to the denaturation of a soluble

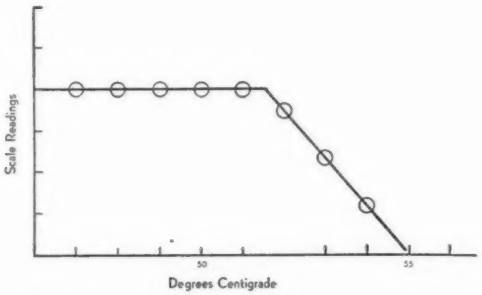

Fig. 2. Typical measurement of shrinkage temperature of surgical gut.

protein and can, therefore, be characterized as a denaturation since the mechanism of both processes is fundamentally the same. Thus, the change in viscosity of a protein solution when denatured is explained as a change in shape of the protein molecule.

The measurement of the shrinkage temperature is conveniently done in the following way (Fig. 1). The catgut attached to a base *B* is suspended in a vertical position in a metal container and submerged in water. The upper part of the gut is attached by means of a battery clamp *C* to a cord which runs over a nearly frictionless pulley *P*, having a weight *W* attached to the free end. The weight is 1 gram heavier than the battery clamp and serves to keep the catgut straight when in a swollen condition. The position of the weight is read against a screen *S* which is covered with a piece of graph paper. The bath is slowly heated and a reading is taken for every degree rise in temperature. Figure 2 shows a typical measurement. The intersection point between the two lines gives the shrinkage temperature which, in this example, would be 51.8 degrees C.

The process of chromicizing catgut sutures is essentially a tanning procedure. In the tanning industry measurements of shrinkage temperatures are more and more replacing the old boiling test as a control of the degree of tanning. Apparatus similar to the one presented here are available commercially for this purpose. For physicians it is interesting that this shrinkage was used as early as 1873 by Engelmann as a physiological demonstration of the phenomenon of muscle movement.

The shrinkage temperature is, as could be expected, a function of *p*H of the solution; thus, undenatured catgut has a shrinkage temperature of about 60 degrees C. in neutral solutions and around 45 degrees C. in solutions of *p*H 3.0. The salt concentration also has an influence and, characteristically, the calcium ion lowers the shrinkage temperature considerably more than any other ion. The condition of the catgut itself (for instance, content of chromium or degree of denaturation) profoundly influences the shrinkage temperature. In our studies, we have not been interested in a study of the influence of *p*H or different salts on the shrinkage temperature but rather in the use of the shrinkage temperature as a means of characterization of the catgut itself. In all the measurements presented we have, therefore, kept the *p*H constant at 6.8 by using Sörensen's phosphate buffer solutions. For further information on this subject, which without doubt is of far-reaching physiological interest, the reader should consult the recently published book of McLaughlin and Theis, in which the chemical significance of the shrinkage phenomenon is discussed in detail.

Most of our digestion experiments have been made in connection with animal experiments and will be described in the following section; however, two experiments, which demonstrate the importance of the shrinkage temperature as a characterization of the catgut suture, will be reported here.

The tryptic digestibility of collagen is, as shown convincingly by W. Grassman, highly influenced by a prior heat treatment. As previously stated, collagen which has not been denatured is practically indigestible by trypsin; however, strands partly or completely heat denatured are digestible and, the more intense the preceding heat treatment, the higher the digestibility.

Heat treatment of collagen in the presence of moisture produces a higher degree of denaturation than a similar treatment under anhydrous conditions. Consequently, catgut manufacturers carry out their sterilization process in the absence of moisture.

Chromicized catgut sutures of three different chromium contents were divided into two groups. The two groups were given different heat treatment (under conditions resembling the sterilization process) resulting in strands of different degrees of denaturation and, hence, different shrinkage temperatures. In another experiment, strands of different chromium contents were given the same heat treatment. In both experiments the shrinkage temperature and the relative tryptic digestibility were determined. The enzyme solution used was a 0.5 per cent solution of trypsin in phosphate buffer at *p*H 6.8; 10 cubic centimeters of the solution was used to 0.4 gram of collagen. The temperature was 36 degrees C. and the digestion time, 48 hours. The results of both experiments are compiled in Table I, and the figures are arranged according to decreasing shrinkage temperatures.

When the figures are arranged in this manner, it is seen that the tryptic digestibility increases when the shrinkage temperature decreases in both experiments. When the heat treatment has been varied (the first experiment), the chromium content does not follow the shrinkage temperature and digestibility. However, in the second experiment where all of the strands have been heat treated in the same way the chromium content follows both the shrinkage temperature and the digestibility in an orderly fashion.

It can thus be stated that surgical catgut is characterized not only by the chemical treatment it has undergone (chromicization or use of other tanning agents) but also by the degree of denaturation caused by the sterilization process and recorded by the shrinkage temperature.

As will be demonstrated later, we have found a parallel relationship in our animal experiments.

THE PROPERTIES OF COLLAGEN SUTURES AFTER PERIODS OF IMPLANTATION IN ANIMALS

Jenkins and Hrdina (4) have found a satisfactory correlation between the absorption characteristics of surgical catgut in animals and in the human. While they worked mainly with dogs, it has been our experience that rabbits may be used to equal or better advantage in this type of work. Consequently, we have used rabbits in most of our *in vivo* experimental investigations.

TABLE I.—EFFECT OF HEAT DENATURATION ON TRYPTIC DIGESTION OF CHROMICIZED CATGUT.

Different heat treatment			Same heat treatment		
Shrinkage temperature	Tryptic digest. per cent into solution	Chromic oxide per cent	Shrinkage temperature	Tryptic digest. per cent into solution	Chromic oxide per cent
67.2	9.4	1.83	61.5	11	1.39
61.7	18.2	1.15	59.5	33	1.18
59.2	28.0	1.83	58.0	50	0.82
57.0	41.4	0.56	55.1	64	0.59
55.8	43.2	1.15	54.2	72	0.48
53.8	90.0	0.56	53.1	95	0.23

Sutures were imbedded in the dorsal muscles of the rabbits while they were under nembutal anesthesia. All implantations were carried out under aseptic conditions. The sutures were passed through the skin and into the muscles of the pelvic region by means of mattress needles about 7½ inches long drawn through the muscles of the back parallel to the dorsal surface of the animal and brought out through the skin in the scapular region. They were tied at each end to wound clips attached to the skin, care being taken to allow a slight amount of slack at each end so as to prevent too much tension being applied to the suture as the animal changed position. The area was then covered with a sterile gauze pad which was held in place by sterile bandages. Finally, the bandages were covered with adhesive tape. This technique is similar to that previously described by Howes.

The sutures were removed after predetermined intervals by loosening the wound clips and freeing the sutures after which they could be pulled out of the muscle without difficulty. The tensile strength was measured on a Scott tensile strength machine. While some investigators have dried the sutures before measuring the tensile strength, we felt that they should be tested in as nearly as possible the same condition as obtain in the tissue. For this reason all sutures were placed between damp towels and the tensile strength measured before any loss of fluid had occurred. Controls were kept between damp towels for 1½ hours before testing since it was found

TABLE II.—DIAMETER OF VARIOUS SIZES OF CATGUT USED

Type	Minimum diameter inches	Maximum diameter inches
L	.004	.006
M	.006	.008
N	.008	.010
O	.010	.013
P	.013	.016
Q	.016	.019
R	.019	.022
S	.022	.025

that such treatment gave results similar to those obtained from sutures which had been in the tissues about 45 minutes. This level was chosen as the control because it was found that catgut sutures decrease in tensile strength as they imbibe fluids from the tissues. The tensile strength level becomes fairly constant after 45 minutes in the tissues, and imbibition of fluids alone does not further reduce the strength. Approximately two thousand sutures were tested in this manner. This method of testing enabled us to determine the functional life of the sutures which we believe to be as important from the surgeon's point of view as the complete absorption time.

EFFECT OF IMPLANTATION IN ANIMALS ON THE TENSILE STRENGTH OF CATGUT SUTURES

In the first phase of this study type Q sutures with a chrome content of 0.6 per cent (Table II) were used. These were implanted in the dorsal muscles of rabbits in the manner described, 6 sutures being placed in each animal. The sutures were removed and the tensile strength measured after periods of 3, 5, 7, 9, 11, and 15 days. Two tensile strength measurements were made on each suture, and the average of 12 measurements made on 6 sutures from the same animal was taken as the final value. The average tensile strength was then plotted against the number of days in the rabbit. The sutures used for any particular series of experiments were all chromicized[1], tubed, and sterilized at the same time so as to eliminate variations in these pro-

[1]All sutures were chromicized by a method which gave uniform chromicization throughout the suture.

TABLE III.—IN VIVO ABSORPTION PATTERN OF CHROMICIZED CATGUT

Days in animal	Chromic oxide per cent	Shrinkage temperature Centigrade	Wet tensile strength (in pounds)	Relative tryptic digestibility (per cent into solution)
Control	1.48	63.2	15.5	6.6
3	1.29	57.8	10.3	39.1
7	1.18	56.3	8.0	44.2
11	1.06	54.8	5.5	77.5
15	0.90	54.2	4.0	73.4

cedures which might affect the rate of absorption. The chrome content of each batch of sutures was determined as well as the shrinkage temperature as a further check on their uniformity.

It was found that the tensile strength decreased in a fairly linear fashion for about 7 days at which time they retained approximately 30 per cent of their original wet tensile strength. From the seventh to the thirteenth day there seemed to be little further decrease in tensile strength (about 10%). From the thirteenth to the fifteenth day there was a rapid decrease so that after 15 days the sutures had little or no tensile strength remaining (Fig. 3).

Plain catgut studied in a similar manner decreased much more rapidly in tensile strength. After 3 days, only 33 per cent of the original tensile strength remained, and all but about 10 per cent of the strength had been lost after 5 days (Fig. 3).

These experiments were then repeated with surgical gut of various sizes (Type L to Type S) and chrome contents. The residual tensile strength curve had the same general shape in all cases and, what seemed more significant, the rate at which the tensile strength decreased was approximately the same regardless of the size of the suture. The exception to this seemed to be the very large sizes, particularly Type S, in which the initial rate of decrease in strength was slightly higher. This was attributed to the increased foreign body reaction produced by these sutures.

By chrome tanning alone it is difficult to make sutures which have a functional life greater than 15 days. In the case of Type Q sutures, it was possible, by increasing the

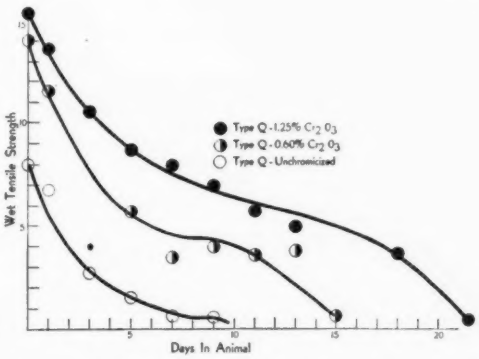

Fig. 3. The effect of implantation in animal tissue upon the wet tensile strength of surgical gut.

chrome content to 1.25 per cent, to extend the life of the suture approximately 6 days (Fig. 3). This holds also for smaller sizes on a percentage basis, but the actual strength of the extreme small sizes is so low that there is no improvement of practical significance. In the case of larger sizes an increased chrome content does not improve the suture appreciably due to the increased foreign body reaction.

To extend the absorption time of a suture appreciably beyond 15 to 18 days other procedures in addition to chromicization must be employed. This was found to be true regardless of the method of chromicization.

It has been assumed by some investigators that the decline in tensile strength of catgut in the tissues is a relatively constant factor. While the results of dry tensile strength measurements may lead to this conclusion, it is evident from the experiments just described that the wet tensile strength measurements of chromicized sutures indicate that the tensile strength drops in a fairly linear fashion for a period and then maintains quite a constant level for a time after which there is a rapid loss until all strength is gone.

As we have found no loss in weight of the strands imbedded in the animal up to periods of 10 days, this characteristic shape of the curve cannot be explained as a consequence of loss of collagen material due to enzymatic activity, but other factors must be involved. In order to follow this problem more closely we have made a number of experiments where

TABLE IV.—EFFECT OF HEAT DENATURATION ON IN VIVO ABSORPTION OF PLAIN CATGUT

Heat treatment	Initial shrinkage temperature degrees	Initial tensile strength (Pounds)	Tensile strength after 7 days (Pounds)	Per cent residual wet tensile strength	Initial digestibility (per cent into sol.)	Digestibility after 7 days (per cent into sol.)
No treatment	61.5	7.7	6.5	88.8	7	27.3
Dried 16 hrs. at 100°C.	55.8	5.9	2.9	49.2	10.8	33.1
Complete sterilization process	47.3	7.0	1.2	17.0	70.1	97.8

we have examined the strands taken out of the animals in the following manner: the shrinkage temperature was measured, the strands were analyzed for chromium, and the relative tryptic digestibility was determined. The results of a typical experiment are presented in Table III.

It was found that there was a decrease in the chromium content and in the shrinkage temperature and an increase in the tryptic digestibility of the suture which paralleled the decrease in wet tensile strength after varying periods in the animal.

The dechromicization of the sutures is probably due to the transfer of the chromium from the collagen to other protein compounds in the surrounding tissue. This is in line with the observation of McLaughlin and Adams (8) who reported that, when chrome leather was immersed in water with unchromicized pieces of hide, there was a dechromicization of the tanned leather and a corresponding chromicization of the untanned pieces. Jenkins (6) and his co-workers have reported that a similar phenomenon takes place in living tissues when chromicized sutures have been imbedded therein. They observed that the phagocytic cells around the sutures took on the color characteristic of chromic catgut to such an extent that for some time after the catgut had been absorbed these chrome stained macrophages simulated the gross appearance of unabsorbed chromic catgut.

The relationship between chromium content, shrinkage temperature and tryptic digestibility has been discussed for *in vitro* experiments in the first part of this paper (Table I). The dechromicization which takes place in the tissue of animals has been shown to bring about a corresponding decrease in the shrinkage temperature and an increase in the digestibility of the suture; however, the increase in digestibility in the tissues is greater than can be accounted for by the loss of chromium. We have shown in the first part of this paper that the degree of denaturation caused by the sterilization process has an effect upon the *in vitro* digestion of collagen sutures. Similar results were obtained by *in vivo* experiments (Table IV). A series of experiments was conducted in which the tensile strength and the tryptic digestibility of plain catgut sutures which had been heat treated to produce different initial shrinkage temperatures were measured after 7 days in animal tissue. The residual tensile strength and the relative digestibility were found to vary inversely with the initial shrinkage temperature. These experiments with plain catgut indicate that, while the products of metabolic activity in the tissue have a denaturing effect of their own upon the collagen which has an influence upon the residual tensile strength and the tryptic digestibility, the denaturation of the suture by the tissue fluids is influenced to a considerable extent by the heat treatment of the suture during the sterilization process. *We can here again emphasize the fact that the initial shrinkage temperature is as important as the degree of chromicization for adequate suture absorption.*

The increase in tryptic digestibility after chromicized sutures have been implanted in tissue is remarkable. While only about 7 per cent of the control strand went into solution under the experimental conditions, approximately 70 per cent was dissolved under the same conditions after 11 to 15 days in the animal (Table III). *For all practical purposes chromicized sutures can thus be considered nonabsorbable at the time that they are imbedded in the animal, but through a process of dechromicization and denaturation they become absorbable.* As a result of these processes they lose tensile strength and gradually become more susceptible to the action of the tissue enzymes.

This mechanism seems to be ideal for a surgical absorbable suture, and any new absorbable suture material which may be introduced in the future probably should have properties which essentially conform to this mechanism.

SUMMARY

A study of the mechanism of absorption of surgical catgut and of some of its absorption characteristics has been presented. The relation of the tensile strength, shrinkage temperature, dechromicization, and tryptic digestibility of sutures before and after implantation in animals were studied. The experimental material presented leads to the following conclusions:

1. The absorption characteristics of the suture are determined not only by the degree of chromicization but also by the initial shrinkage temperature.

2. The wet tensile strength of a chromicized suture decreases in a fairly linear fashion for a time after which there is a period during which there is little further loss of strength followed by a rapid decline until little or no strength remains.

3. A decrease in shrinkage temperature parallels the loss of tensile strength.

4. The chromium content of a suture decreases during the period in which it is in the tissue.

5. There is an increase in tryptic digestibility proportional to the time of implantation.

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THE EFFECT OF THE ANTICOAGULANTS ON POSTPARTUM BLEEDING

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THE clinical use of the anticoagulants, both heparin and dicoumarol, has extended continuously since their original introduction. They are not only accepted agents in the therapy of intravascular clots, but their routine administration to surgical patients for prophylaxis has also been suggested and investigated (1, 2). The use of these drugs in puerperal thrombophlebitis has been limited, however, due apparently to a reluctance to administer them to patients experiencing vaginal bleeding, and the fear of postpartum hemorrhage. Pfeiffer and Sain specify that the bleeding of the puerperium represents a definite contraindication to the use of the anticoagulants, although they site no studies to justify this statement. Davis and Porter have more recently reported the use of dicoumarol for thrombophlebitis occurring in the puerperium, but their data includes no estimation of the influence of the drug on the vaginal bleeding other than a statement that they observed no instances of gross hemorrhage in their patients, and we have been unable to find studies which record measurements of postpartum blood loss during heparin and/or dicoumarol therapy.

In the face of the known incidence of postpartum thrombophlebitis and phlebothrombosis (7), it was felt desirable to have more accurate information on this subject, and the present paper reports measurements of vaginal blood loss in patients receiving dicoumarol and heparin during the early puerperium.

Materials and methods. Blood loss studies beginning 1 hour postpartum and continuing throughout the period of hospitalization were made on 30 consecutive primiparous patients. All the patients had reached term and had uncomplicated labors with spontaneous delivery or outlet forceps; episiotomy was performed on each. With the exception of the drugs under study, all of these patients were on a similar therapeutic program. Vitamin K was given to none of them; the same anesthetic agent (cyclopropane) was used in all deliveries; the oxytoxic schedule included ergotrate (1/320 grain) intravenously following the delivery of the placenta, and the same dose administered by mouth 3 times a day for the first 3 postpartum days.

All perineal pads from each patient were collected over the period of time the patient was in the hospital. The pads of the preceding 24 hours were washed out daily in a measured amount of water, and a hemoglobin determination was made on the wash water. While this method was checked for accuracy with known amounts of venous blood distributed over several pads and dried an equivalent length of time, no attempt has been made in this report to reduce to grams of hemoglobin the readings obtained. The figures serve for accurate comparison between the group of controls and the treated patients, and the relative blood loss rather than the absolute blood loss has been our interest.

In addition to the blood loss data, prothrombin levels expressed as percentage of normal (Quick) were obtained on the control group and dicoumarol treated patients as well as the clotting times (Lee and White) on the heparinized patients and on controls.

Controls. The 11 patients who served as controls uniformly showed the marked elevation of prothrombin level which has been noted in the normal postpartum patient (6). Readings as high as 130 per cent were obtained (second day following delivery), and with the exception of one reading of 85 per cent on the third postpartum day, no patient fell below 100 per cent until after the fifth day. The average daily prothrombin levels among these patients, starting with the first post-

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partum day, were: 108, 111, 112.5, 113.25, 100.1, 109.2, 109, 101, 98 per cent. There were not enough patients in this group who remained after the ninth postpartum day to make the average figure of value. These prothrombin percentages are plotted graphically in Figure 1 as the dotted line (*A*). The solid line (*B*) represents the average blood loss of this control group during the same period of time.

Dicoumarol. Fourteen patients were given dicoumarol in doses adequate to depress their prothrombin levels to the therapeutic range. Three hundred milligrams were given during labor, 200 milligrams each of the first 2 days, and subsequent dosage was adjusted by the prothrombin determinations. In general, it was felt desirable to have the prothrombin percentage rising toward normal at the time of discharge, and the drug was discontinued 24 to 48 hours before the patient was to leave the hospital. The average daily prothrombin times for these patients, starting with the first postpartum day were: 90.7, 54, 33, 37.3, 20.6, 43.5, 37.7, 54.6, and 63 per cent. At least 12 of the patients are represented in each daily average except the first (6 patients), the 6th (10 patients), and 9th (7 patients). On these days technical difficulties or discharge from the hospital interfered with obtaining prothrombin readings on a larger group. The broken line (*C*) in Figure 1 records these levels.

The blood loss for this group is shown in the broken line (D) on the same chart. It will be seen that there is no significant difference between the average blood loss of this, the treated group of patients, and the controls (line *B*). The variation in the two curves on the first 2 days is not great and is not related to the period of prothrombin depression. The 5 day period that the prothrombin level was maintained below 50 per cent (i.e. more than 16.25 seconds undiluted) was perhaps brief compared to the period sometimes required for therapy, but the blood loss at the end of this time had dropped toward the nonmeasurable point, and we could see no advantage in prolonging the period of treatment. In one patient whose medications were continued through an oversight, the prothrombin level was maintained below 10 per cent (over 37 seconds undiluted) her 7th, 8th, and 9th days postpartum. During this time the patient was ambulatory, but her blood loss was small and did not differ from that of the control group.

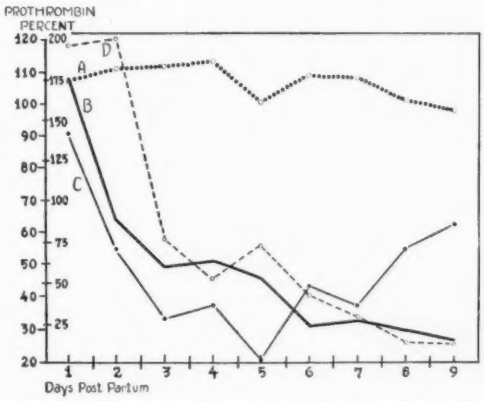

Fig. 1. The scale to the left represents the prothrombin percentage from 20 to 120. Curves *A* and *C* give the prothrombin readings for control and dicoumarol patients respectively. Curves *B* and *D* record blood loss figures for control and treated patients respectively plotted against the arbitrary scale (0-200) on the right.

It can be noted from the results as recorded in lines *B* and *D* that if any given postpartum day is selected, the blood loss of the treated patients is not significantly more than, or is less than, that of the controls. The total blood loss, arrived at by adding the arbitrary figures for each day together, differs but slightly between the two groups, with the treated group having more. No correlation between blood loss and prothrombin rate could be noted in the dicoumarol treated patients; the greatest blood loss was on the second day, the lowest prothrombin percentage was on the fifth day.

Additional observations. Initially in the experiment when marked differences in blood loss were considered possible, hematocrit readings were taken every other day on all patients. It was felt that these would provide a more accurate index than would hemoglobin determinations of the effect on the patient of any excessive blood loss. There were no episodes of excessive blood loss, and the hematocrit remained comparable between controls and treated patients. There was no alternation in the degree of uterine involution at

the time of the patient's discharge from the hospital, nor were any toxic side effects noted.

Bleeding and clotting times obtained on the nursing babies showed prolongation in over one-third of the cases. These reactions were not consistent: in 2 cases both were prolonged, in the other 3 only the clotting time (capillary tube method) was increased. It is not felt that these studies performed on toe or heel blood are sufficiently delicate that the results would bear close scrutiny. In view of the report by Field, however, that rat litters nursed by dicoumarolized females showed hemorrhagic tendencies (7), it might be wise to consider weaning a baby whose mother required prolonged medication with dicoumarol.

Heparin. The action of heparin is more rapid, and there has been an increasing tendency in the presence of the indications for anticoagulant therapy to administer heparin the first 24 or 48 hours while the slower acting dicoumarol is having its effect (6). Accordingly, the patients in this study receiving heparin were maintained with prolonged clotting times for only a 24 hour period on either the first or the second day postpartum. Four cubic centimeters of heparin were administered intravenously, and beginning 4 hours later, the same dosage was administered by the intramuscular route every 4 hours. Clotting times were taken every 2 to 3 hours. Only 5 patients were followed in this manner, but the results in all were consistent, no patient varying more than 6 per cent from the average of the group, and it was felt that a definite index was obtained of the amount of blood lost by the heparinized patient.

Results. The clotting times of the controls checked during the first 48 hours postpartum were all normal (average 7½ minutes), and a significant puerperal alteration similar to that observed in the prothrombin time was not found. During the 24 hour period of treatment in the heparinized group, this clotting time was maintained between 20 and 25 minutes with the exception of 1 patient who, on the dosage outlined, remained between 15 and 18 minutes. During the entire first postpartum week, the blood loss on these patients was the same as that of the controls. There was neither an immediate nor a delayed effect from the heparin administration. Two of the episiotomy wounds, however, developed hematomas, and one of these suffered a partial breakdown. Aside from this complication, the treated patients and the control group presented the same findings.

SUMMARY AND CONCLUSIONS

No patients with postpartum thrombophlebitis were treated, and the present note is not concerned with the therapeutic status of heparin and dicoumarol in this condition. The study was undertaken only to determine whether or not, should these drugs be indicated, the vaginal bleeding prohibited their use. Although the present series is not large, the patients have been followed carefully, and we are unable to find evidence that the anticoagulants significantly increased puerperal blood loss. The customary precautions in connection with the use of these drugs should be scrupulously observed (1), and the weaning of the baby is to be considered, but the data obtained would indicate that heparin and dicoumarol are not necessarily contraindicated in the postpartum patient.

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TALC GRANULOMA

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DESPITE many reports on the dangers resulting from the use of talc many surgeons remain skeptical and continue to use it as a powder for gloves. A study of the occurrence of granulomatous lesions produced by talc and their mode of production, therefore, seemed warranted.

The material reported in this paper is part of the data derived from a study of birefringence in tissues and an investigation of changes in tissues in human beings and in laboratory animals produced by doubly refractile foreign bodies, made visible by use of polarized light microscopy. In the main only the data on talc and the study of the reaction of tissue to talc will be recorded herein although other phases of the entire study will be referred to from time to time when they are pertinent.

THE PROPERTIES, USES, AND DANGERS OF TALC

Talc is a hydrous magnesium silicate with a melting point of 1,380 to 1,530 degrees C. Commercially dispensed talc consists of mixtures of talc, serpentine, dolomite, or tremolite. Reports on the solubility of talc vary from 0.2 to 100 milligrams per 100 cubic centimeters because each investigator has a different interpretation of what constitutes a particle in solution. Talc moieties are complex and exert a definite effect on the environment without being in actual solution themselves.

The material leached out of a talc crystal during suspension is not the same as the parent substance. The degree of hydration of this derivative substance determines its toxicity. For example, a mole of alpha silicic acid may bind as many as 330 moles of water. The size, shape, and cleavage of a talc particle and its surface energy affect its so-called solubility. In the body, alteration of the *p*H and the presence of protein in tissue fluids alter the size and characteristics of the dispersed aggregates.

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Abridgment of part of a thesis submitted by Dr. Lichtman to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the degree of Ph.D. in Surgery.

To demonstrate these facts, talc and asbestos particles were placed in water, saline, body fluids and macerated tissues for 6 months. When these specimens were examined under polarized ight, myriads of particles in brownian movement were seen in suspension. Particles of this dispersed size (0.5–10 microns) are the ones that do the greatest damage.

Talc is used extensively and may find its way into the body in many ways (Table I). The dangers of talc were first recognized by those interested in inhalation of this substance by miners and processors of talc (31). Extensive studies were made on the incidence and importance of talc pneumoconiosis (2, 7, 8, 12, 15, 19, 20, 27). The general impression was that talc produces a fine nonprogressive fibrosis.

Talc has been administered to animals by dusting (11, 12, 19) and injection into veins (12) and lymphatics (28). Its introduction into the testes of the guinea pig caused marked proliferative reaction. Tremendous variation was noted in the response of different tissues and of the same tissues in different individuals and species.

Pleural poudrage of talc was suggested for the production of selective pleural adhesions preliminary to operations on the lungs (4) but it was noted that it might increase susceptibility to tuberculosis (5). Talc has been rubbed on the pericardium in an effort to produce parasitic myocardial circulation (3, 24, 29, 30).

In 1933 Antopol reported 6 cases in which talc and lycopodium powder formed granulomas after operations. Since then granulomas and adhesions producing intestinal obstruction have been frequently attributed to talc introduced by surgeons' gloves (6, 9, 10, 13, 14, 17, 18, 21–23, 25, 26). It has been reported that 22.6 per cent of surgeons' gloves are perforated during operations permitting seeding of talc from the finger tips (32).

CLINICAL DATA ON LESIONS PRODUCED BY BIREFRINGENT PARTICLES FROM VARIOUS SITES

Many talc granulomas were discovered by examination under polarized light of tissues obtained in cases in which there were adhesions, unusual scars, nodules, sinuses or granulomas, in which tuberculosis was in an unusual site or in which multiple operations had been performed.

TABLE I.—ROUTES, OCCUPATIONS, AND USES OF TALC WHICH MAY PERMIT ITS INTRODUCTION INTO THE HUMAN BODY

I. Through air passages: inhalation for long periods of high concentrations of talc
   A. Mining, processing, and packing of talc
   B. Dusting rubber for prevention of deterioration and sticking
      1. In factories
      2. In operating rooms
   C. Scouring and polishing with talc powders
II. By mouth
   A. Bleaching agent for barley
   B. Cleansing agent for beans, coffee, corn, peas, peanuts, and barley
   C. Dusting agent (with starch) and coating for molds and tables in manufacture of candy and chewing gum to prevent sticking
   D. Packing and conserving agent for fruits and vegetables
   E. Binder in pills and lubricant for tablet dyes
   F. Filtering medium in refining and purifying sugar
   G. Ingredient of tooth powders and tooth pastes
   H. Ingredient in glazes, coating and filler for paper used for wrappings for foodstuffs
III. By other routes
   A. Coating of talc on vaginal and rectal suppositories
   B. In antiseptic dusting powders used on wounds
   C. In cosmetics and dusting powders for the skin
   D. As a preservative and lubricant for rubber gloves used in operations

The mere presence of talc in a microscopic section was not considered significant because talc is frequently suspended in the air in operating rooms and because the specimen may be handled with rubber gloves in the laboratory and thus talc may be added during the preparation of the section. Gauze used to wrap specimens may add cotton fibers too. In fact, it was difficult to find a section without talc on it when the laboratory was adjacent to the operating rooms. Because of these facts, only those crystals which were associated with a definite surrounding inflammatory response were considered as significant. The nature of this work necessitated the elimination from consideration of any questionable particles and it was considered wiser to err on the side of rejection of any particle around which the foreign body response was not clear cut.

Peritoneum. In 100 consecutive surgical cases in which dense adhesions resulting from multiple previous operations on the abdomen were found, specimens of the adhesions were sectioned on the freezing microtome and studied by means of polarized light under the microscope. In 21 (21 per cent) of these cases talc crystals were found with a surrounding foreign body response. In 6 (6 per cent) a large amount of talc was present and the reaction was extensive. While the degree of reaction in these 6 cases was so great, and there was no doubt of the part played by the talc in the production of the adhesions, the concentration of the talc and distribution of the reaction in the other 15 cases did not permit a definite conviction as to the rôle of the talc. Cotton lint fibers also were found in foreign body giant cells in these cases.

Nodular lesions of the peritoneum were examined next. In 4 cases definite talc granulomas were found. In these 4 cases small yellowish white nodules studded the peritoneum, mesentery, and omentum. In 1 of these cases lycopodium granules had contributed to the granulomas.

The tubercle-like appearance of the granulomas in these cases prompted us to re-examine tissue removed in cases in which a diagnosis of noncaseous tuberculosis of the peritoneum had been made. In 6 of the 102 cases of this condition in which lesions considered to be those of noncaseous tuberculosis were examined, the tubercle-like lesion had been produced by talc. In 5 other cases in which talc was not present, some of the tubercles apparently were actually foreign body responses to cholesterol esters contained in the nodule. Thus by the use of polarized light microscopy, the talc and cholesterol ester crystals, which were obscure on routine examination, became apparent. During examination of peritoneal lesions 6 cases were found in which birefringent vegetable fibers, originating from a previous perforation of a peptic ulcer, had formed granulomas. These were made obvious by the use of polarized light.

When concomitant trauma, abrasion, and infection had occurred, the talc if present in high enough concentration had produced dense adhesions with proliferation of a moderate amount of fibrous tissue. The granulation tissue in the adhesions was well vascularized. There was not enough fibrous tissue to cause obliteration of the vessels such as occurs in granuloma caused by silica. When simple inoculation of the talc had occurred with little infection or trauma, the talc tended to form plaques and nodular lesions were produced rather than dense adhesions.

These findings suggest that great caution should be observed about accidentally introducing talc into the peritoneal cavity in cases of tuberculous peritonitis. It would seem that talc may accelerate the progress of a tuberculous infection of the peritoneum.

Scars, sinus tracts, and lesions of skin. Nodules developing in scars left by operations are a source of concern to the surgeon and the patient. The patient is anxious about the cosmetic effect particularly if the scar is about the face and neck

The surgeon is fearful of tuberculosis in scars of the neck and of a recurrence or a transplant in operations for the removal of a malignant lesion. In many cases the nodule may be caused by talc introduced on rubber gloves during the first operation. Small nodules near the skin may be produced by suture material.

In the course of this study 5 cases were encountered in which nodules occurring in the scar following thyroidectomy were considered lesions of noncaseous tuberculosis. On re-examination by polarized light microscopy 3 of the nodules were demonstrated to be talc granulomas. In 1 of the cases the nodule had developed rapidly 5 years after thyroidectomy in a scar which had been almost invisible. Two cases were found in which a draining sinus followed excision of a cervical lymph node. The sinus tracts were assumed to be tuberculous but examination revealed that the granulation tissue lining the tracts was loaded with talc. In another case a nodule, which developed in a scar on the forehead 36 years after a laceration, was originally considered to be due to noncaseous tuberculosis. Microscopic examination with polarized light revealed a pseudotubercle reaction produced by large masses of talc (Fig. 1).

Tissue from 26 operative scars on the abdominal wall which were excised because of the presence of an unusual appearing nodule or a draining sinus were studied for birefringent foreign bodies. The finding of suture material was common. In 5 scars the thickening or sinus was due to talc granuloma. One of these talc granulomas followed gastroenterostomy. In the second case a persistent draining sinus had developed 7 years after appendectomy. The tract was lined with talc granulation tissue (Fig. 2). In the third case, appendectomy had been performed 8 years previously. A firm nodule was found at the lower angle of the scar. The patient complained of menorrhagia and gave a history of repeated spontaneous abortions. The nodule was found to be continuous with a firm plaque to which a myomatous uterus was adherent. The surgeon suspected an unusual malignant lesion but section of the tissue revealed talc granuloma. In the fourth case operation was performed because of a cystic mass in a scar in the lower part of the abdominal wall. The cyst was filled with necrotic material and its walls were lined with talc crystals. In the fifth case a similar sinus appearing after herniorrhaphy was believed to be due to a buried silk suture, but section of the excised wall revealed that talc was the cause of the persistence of the sinus.

A persistent draining lumbar sinus which appeared after nephrectomy revealed large amounts of talc in its walls. Four persistent ulcers of the skin, 2 in the groin and 2 in the perineum, were excised. Examination revealed large amounts of talc with surrounding foreign body reaction. On the surfaces of most skin lesions of this type some talc can be found; no doubt it was dusted on by the patient for fastidious reasons. In this study the talc was associated with evidence of a foreign body reaction before it was implicated as a possible cause for the persistence of the lesion.

The appearance of a nodule in the scar after removal of tissue from the breast for biopsy, even if the original lesion was benign, or after mastectomy for a malignant lesion is a source of great concern. We studied 1 case in which a nodule appeared 2 months after mastectomy for carcinoma of the breast. The nodule was excised to see if it represented a local recurrence. In the initial pathologic report the diagnosis was noncaseous tuberculosis. Microscopic examination with the aid of polarized light revealed that the nodule was a talc granuloma with a tubercle-like response.

The development of talc granulomas in many respects is similar to that of silicosis. For some miners exposure to high concentration of silica dust for more than 40 years does not result in clinical silicosis. When silicosis does develop, the symptoms appear any time from 6 to 30 years after the onset of exposure, and when the process begins, its progress is steady. In the few cases of talc granuloma encountered in which the lesions developed in scars, the palpable nodule appeared from 2 months to 36 years after the talc was implanted in the skin. In 1 case the talc doubtless had been dormant for 36 years, then some unknown stimulus set up a proliferative reaction and a nodule formed. The course was rapid and in a short time the nodule broke down and serous fluid began to drain. It is difficult to explain why talc will remain in the skin with little obvious reaction in some individuals and then many years later instigate a foreign body reaction. The finding of small amounts of talc in some scars, with only enough reaction to surround the crystals, suggests that in most individuals talc never excites much of a response. Only an occasional individual has a granuloma. In silicosis it is possible that the addition of infection starts off the conglomeration of small discrete nodules that produces clinical silicosis. In talc granuloma in the skin, it is likely that trauma to the scar may provide the added injury that starts the formation of a nodule. This will be discussed further in the experimental production of talc granuloma.

Cervix and rectum. The cervix and rectum are occasionally the sites of talc granulomas resulting

from the prolonged use of suppositories dusted with talc, dusting powders, and other medicaments containing talc. Although the intact mucus membrane will not adsorb talc, the conditions prompting the prolonged use of rectal and vaginal medication are usually associated with erosions, ulcerations, and fissures. These granulating surfaces may adsorb talc particles and include them in a foreign body reaction.

In 25 consecutive cases in which biopsy revealed chronic cervicitis, the tissue removed was examined under the polarized light microscope and talc was found to have caused some reaction in 2 of them. In neither of these cases was the degree of reaction sufficient to account for the entire inflammatory response but it certainly may have been a factor in causing the persistence of the lesion. In these 2 cases, the lesion was suspected of being malignant on gross examination.

Two hundred specimens of inflammatory rectal mucosa were examined after removal in the course of hemorrhoidectomies. Although talc was found in many of these tissues, none of them showed a marked foreign body response and only 12 showed a minor foreign body response to the adsorbed talc.

In addition 2 definite talc granulomas were found in which rectal stricture was so marked that radical resection was performed.

Granulomas produced by foreign bodies such as oil or talc, introduced into the rectal tissues by injection for the treatment of hemorrhoids, by a gloved finger covered with talc or petroleum jelly, or suppositories aided by trauma, have on occasion been considered as malignant by most experienced diagnosticians. Biopsy may reveal a nonspecific inflammatory picture or the presence of pseudotubercles may suggest tuberculosis. Time can be saved by the examination of fresh-frozen sections under polarized light. On this examination the talc crystals as a center of the foreign body reaction are immediately apparent or the oleoma is self-evident. If the pathologist does not give such a definitive diagnosis, the patient will be subjected to repeated biopsies to rule out a malignant lesion. The granuloma may cause marked obstruction and radical therapy may be necessary.

The gall bladder. The finding of the following talc granuloma in the gall bladder was accidental and not by intentional investigation. It was encountered in a study of the cholesterol esters in the gall bladder.

Eleven years previously the patient had undergone cholecystostomy for cholecystitis with cholelithiasis. Little relief resulted and postoperatively the patient complained of pain in the epigastrium and a tender mass in the right lower quadrant of the abdomen. Because of the persistence of these symptoms for 11 years, cholecystectomy was performed at which time dense adhesions to the stomach and colon were encountered. The wall of the gall bladder was markedly thickened and the pathologist suggested that a sarcoid of the gall bladder might be present. The adjacent lymph node was considered tuberculous. On re-examination with the aid of polarized light it was found that the gall bladder and lymph node were loaded with talc and cholesterol ester crystals. The close-packed pseudotubercles closely resembled a sarcoid lesion (Fig. 3).

The type of cholecystostomy tube used 11 years before was not known but it probably carried the talc in to the gall bladder and in all probability some petrolatum jelly too.

Gastroenteric stomas. Sixty specimens from the walls of excised malfunctioning gastroenteric stomas were subjected to examination by means of the polarizing microscope. In 8 (13.3 per cent) of them a large amount of talc was found in the wall around the stoma and a marked foreign body reaction was associated (Fig. 4). In 8 others a limited amount of talc was found. Foreign body reactions to the suture material used in the creation of the anastomosis also were present.

The talc in these cases may have been derived from the rubber-shod clamps used in making the anastomosis. The part the talc plays in malfunction of a gastroenteric stoma of adequate physical size is a matter of conjecture and a positive opinion would be perilous. Some evidence of the profound effects on the intestinal wall of intramural talc granulation tissue can be derived from the experimental work on the production of fecal fistulas which will be reported later in this paper.

It was deemed wise to compare this series in which the gastroenteric anastomosis was taken down because of poor function with a group of cases in which it was excised because of an anastomotic ulcer. In this latter group the function of the stoma was usually good. Tissue from the site of 100 such stomas was examined; the tissue from 4 (4 per cent) contained a marked amount of talc and from 3 a slight amount. The greater incidence of talc at the site of the malfunctioning stomas suggests the possibility that the granulomatous tissue in the wall of the stoma contributed to the poor function.

NONCASEOUS TUBERCULOSIS OF ILEUM AND REGIONAL ENTERITIS

From the findings presented thus far it can be seen that on occasion talc granuloma may simulate tuberculosis and that it may be diagnosed as tuberculosis. While large talc crystals can be seen in ordinary light when the field is darkened, particles between 0.5 and 10 microns in diameter

which cause most of the damage can be seen clearly only with the aid of polarized light. In view of the number of substances and products of inflammation which may produce pseudotubercles in some species (Table II), the unsupported morphologic diagnosis of hyperplastic noncaseous tuberculosis in cases in which tubercle bacilli are not demonstrable by staining, culture or guinea pig inoculation is subject to question. Many pathologists now call such lesions sarcoids.

So-called regional enteritis often consists of hyperplastic tissue in which there are pseudotubercles. It occurred to us that before 1932 many lesions now called "lesions of regional enteritis" would have been classified as hyperplastic noncaseous tuberculosis. In spite of the controversial nature of the problem it was decided to re-examine under polarized light the specimens of hyperplastic tuberculosis of the ileocecal region seen at the Mayo Clinic. By examination of multiple sections of the specimens and review of the history in 198 of these cases, the impression that a large number of these would be considered cases of regional enteritis in the present day was verified. One aspect of this problem is of interest in this study. In 49 of the 198 cases of so-called hyperplastic tuberculosis birefringent crystalline material was found. Extensive study of specially stained sections failed to reveal tubercle bacilli in any of the tissue available for study in these 198 cases. In 33 of the 49 cases, the amount of the crystals was large and the reaction appeared to be a result of the presence of the crystals (Fig. 5). In 16 of the cases the amount of the crystals was small, and no definite conclusions could be drawn about their relation to the reaction. The magnitude of birefringence of the crystals in all 49 cases was high and negative in sign. As far as the petrographic analysis could go, the crystals resembled talc crystals. They were subjected to incineration study (Fig. 6) and the silicate nature was verified by comparison with adjacent serial sections. The crystals were not calcium deposited by a tuberculous infection for the birefringence of these apatite crystals is of low magnitude and the sign is positive. Furthermore, calcium salts, when stained with polychrome methylene blue take on a blue color, and do not provoke a foreign body reaction. Efforts to identify these crystals were fruitless.

Experimental investigation was limited to the roundabout method of trying to reproduce the lesion. Since only half of the patients had had previous operations involving the right lower quadrant of the abdomen, it could not be assumed that the crystals had been accidentally placed in the abdomen by the surgeon at the first operation.

TABLE II.—SUBSTANCES WHICH HAVE BEEN REPORTED TO PRODUCE STRUCTURES RESEMBLING MORPHOLOGIC TUBERCLES WITHOUT CASEATION IN SOME SPECIES*

Bacteria: Mycobacterium tuberculosis; Mycobacterium lepræ; Malleomyces mallei; Pasteurella pestis and coal dust impregnated with Bacillus subtilis; Pasteurella pseudotuberculosis; Brucella abortus; Brucella melitensis; Pasteurella tularensis.
Fungi: Aspergillus; Blastomyces; Actinomyces; Trichophyton; Coccidioides and Actinomyces asteroides.
Plants: Lycopodium (club moss); finely divided cork and pepper.
Protozoa:
Sporozoa: Sarcosporidia.
Spirochetes: Treponema pallidum.
Platyhelminthes:
Nematodes: Ascaris; Filaria.
Trematodes: Schistosoma mansoni.
Cestodes: Echinococcus.
Chemical and derived substances: mercury; talc; fibrous sericite; powdered dry silica gel; cholesterol esters; oil of turpentine and euphorbium; the lipid, phosphatide or protein extracts of tubercle bacilli; lipid extracts of liver, grass bacilli or colon bacilli, and mineral oils.

*Sarcoid, acne rosacea, and other skin lesions which may represent allergic responses to the tubercle bacilli, and keratinizing squamous cell epithelioma sometimes resemble noncaseous tubercles.

Study on animals. An attempt was made, therefore, to determine whether the crystals could have been adsorbed from the gastrointestinal tract. Six adult white rats were selected for this study. They were fed for 30 days on stock ration plus talc crystals so that 10 per cent of the ration consisted of talc. The diet was then changed so that it contained 20 per cent talc and this ration was fed for 12 days more. There was no change in the bowel habitus and the rats showed no ill effects from the high concentration of talc. They seemed to thrive on it. Polariscopic examination of the stools revealed that they were loaded with talc. Feeding of talc was discontinued after 42 days and the rats were allowed to eat straight stock ration for 9 days so that the talc in the gastrointestinal tract would have a chance to empty out. Then the animals were killed and necropsy performed. Fresh frozen sections were made of all the organs and were examined by means of polarized light.

On opening the abdomen, the peritoneum appeared normal and there was little of note other than a slightly thickened mesentery and marked prominence of the Peyer's patches along the terminal part of the ileum. Sections of the terminal part of the ileum showed segments in which there was infiltration of the villi by lymphocytes and eosinophils (Fig. 7). The connective tissue between the muscularis mucosae and the tunica muscularis showed more birefringence than it nor-

mally does. The muscle layers were normal except for the infiltration of lymphocytes in the regions of vessels and lymphatics. There was moderate hypertrophy of the nerve tracts and ganglionic plexuses. The lesion diminished in the proximal portion of the ileum and both the jejunum and stomach showed little change. Examination of the colon gave negative results.

Birefringent talc could not be found in the intestinal wall or other viscera. The liver was normal except for a few regions in which small local hemorrhages were found. In the tubules of the kidney there was found similar evidence of the rupture of a few capillaries. There was slight early acute glomerulitis (Fig. 8). Polymorphonuclear leucocytes were present in some glomeruli in small numbers and occasionally the lesion had extended and obliterated the tuft which was replaced by a granular mass studded with pycnotic nuclei. There was some hyperplasia of the germinal centers of the spleen (Fig. 9) but the most prominent change was seen in the blood sinuses. These were distended with red blood cells and lymphocytes. The eosinophils were moderately increased. The amount of connective tissue was more than usual. Some areas showed extensive deposits of hemosiderin.

The interpretation of these minimal findings is difficult. The initial dose of talc was intentionally high, yet it was doubled because the rats seemed to thrive on the first dose. Most of the effects may have been produced mechanically by the large amount of talc in the intestinal contents. But talc is not particularly hard. It is softer than the bismuth, calcium, and barium salts that occasionally find their way into the intestinal tract. It was hoped that the local mechanical effects would have cleared up in the 9 days between the last dose of talc and the termination of the experiment. No evidence of birefringent talc was found in the walls or lumen of the gastrointestinal tract. Similarly none was found elsewhere in the body. Probably a longer interval after the last dose of talc would have been more satisfactory. But this much can be gleaned from the experiments. The lesion, whatever its mechanism, was segmental and most prominent in the terminal part of the ileum. This is the site of predilection of many of the granulomatous lesions of the intestines. If the lesion was produced by a colloidal fraction leached from the talc, the inflammatory reaction would be the response anticipated and its locale would be the terminal portion of the ileum. The slight endothelial reaction present in the kidney and to a lesser extent in the spleen and liver was suggestive of the lesions that have been described following the injection and oral ingestion of fresh silicic acid. The abundance of eosinophils in the inflammatory response is an occasional characteristic of lesions produced by talc. There was no evidence of the absorption of any particles large enough to be visualized by polarized light but colloidal particles are not visible. The rats did not show symptoms or change in bowel habitus. However, the changes in the kidneys suggest that a colloidal fraction of talc may be absorbed and excreted via the kidneys.

RÔLE OF TALC IN PERSISTENCE OF FECAL FISTULAS AND RESPONSE OF ILEUM TO INJECTION OF TALC

In a previous report (16) on 408 surgically treated fecal fistulas, it was found that talc, placed in the abdomen during the course of previous operations, had produced talc granulomas in the walls of some of the fistulas. Fifty of the more persistent fistulas, in which there was no apparent cause for the persistence of the fistulas, were selected for detailed microscopic study. In this smaller group, talc was demonstrated in 4 fistulas (8 per cent). Because of the relation of the talc to the inflammatory reaction, and the organization of the fistulas, it was assumed that the talc was a factor in maintaining the fistulas.

In order to test the validity of this assumption and incidentally to study the pathogenesis of talc granuloma, we decided to determine whether talc in the serosa of the bowel would alter the natural tendency of the proximal limbs of isolated loops of intestine to close. It was not the purpose of this work to study the effect of talc alone but of talc plus infection.

The same batch of talc was used throughout this work for uniformity. It was not fresh since it was the variety used in the operating room. A 1 per cent suspension was made up and sterilized. Since the talc was in suspension, the activity was less than that of the dry fresh dust.

Six dogs were subjected to operation under ether anesthesia with aseptic technique. A midline abdominal incision was made. About 40 centimeters of the distal portion of the ileum was selected for isolation. Suitable vascular arcades were identified and the marginal vessels were cut between ligatures. The bowel was cut between clamps and the 40 centimeters of ileum with its blood supply intact was isolated. Continuity of the ileum was established by side-to-side anastomosis (Figs. 10 and 11).

The isolated segment of ileum was divided between clamps into two halves 20 centimeters long. Two stab wounds were made through the abdom-

Fig. 1. Talc granuloma in scar of forehead which originally was considered as noncaseous tuberculosis because of the characteristic hard tubercles and extensive fibrosis. Polarized light revealed a wide distribution of talc (×88; polarizer at ½ extinction to show surrounding lesion).

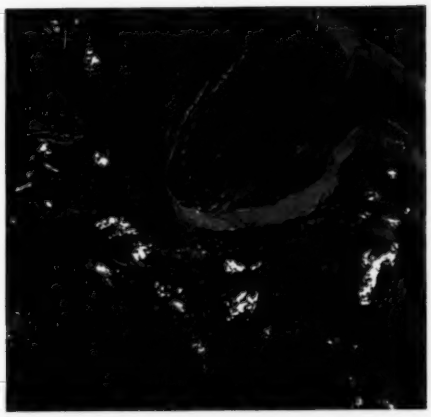

Fig. 2. Talc granuloma in an inflammatory sinus tract from the abdominal wall. There was extensive fibrosis (×132; polarizers at ½ extinction to show background).

inal wall on each side of the incision as exits for the two ileal loops thus created. The peristaltic direction was marked carefully. The ends of the loops were brought out through the appropriate stab wounds. The ends of the more proximal of the two loops were brought out to the right (right side of the dog) of the incision (Fig. 12*a* and *b*) with proximal end cephalad and distal end 5 centimeters caudad. The more distal of the two loops was brought out to the left of the incision (Fig. 12*c* and *d*) in a similar manner again maintaining peristalsis in a caudad direction. The proximal limb of the right loop and the distal limb of the left loop were treated with talc; this procedure thus permitted each dog to act as a control on itself. Two cubic centimeters of the 1 per cent talc suspension was injected subserosally as follows: A syringe attached to a short bevel 27 gauge hypodermic needle was used. Multiple punctures were made in a segment 1 centimeter long of proximal end of right loop (Fig. 11*a*) and the distal end of the left loop (Fig. 11*d*). A total of 40 milligrams of talc was used in each dog. A few wheals were raised in the parietal peritoneum near the proximal end of the proximal loop (*a* in Figs. 11 and 12). Small amounts of talc suspension invariably escaped into the peritoneal cavity. Control punctures were made in the untreated ends of the loops. The abdomen was closed and the four projecting ends of the two loops were fixed to the abdominal wall by two catgut sutures (Fig. 12). The operative trauma was intentionally extensive. This was done in an attempt to reproduce conditions as nearly as possible like those in the cases in which fecal fistulas occurred, for questioning of the patients who had postoperative fecal fistulas had revealed that the original operation was frequently an emergency procedure and there was a stormy postoperative course owing to peritonitis.

Postoperatively all the animals showed signs of peritonitis. Three weeks after operation induration about the intestinal stomas subsided and it was possible to begin observations. Six weeks

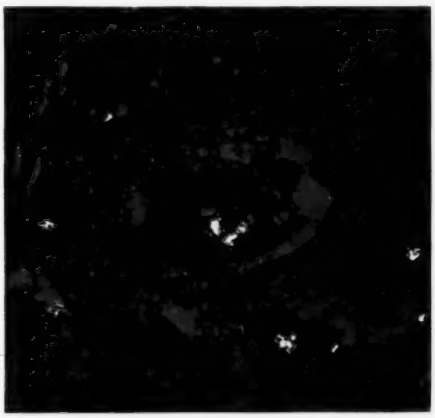

Fig. 3. Sarcoid of the gall bladder was suspected at first; actually the tubercles represent a foreign body response to both talc and cholesterol esters. Several cholesterol ester liquid crystals may be seen in the gallbladder; nearer the mucosa there were talc crystals also. Both substances were found in the sentinel lymph node (×97; polarizer at ½ extinction to show surrounding lesion).

Fig. 4. Talc granuloma found in a gastroenteric stoma dismantled and excised because of malfunction (×117; polarizer at total extinction).

after operation it was obvious that the treated loops were open and the untreated loops were closing. Although it was anticipated that the distal limb on the right would remain open because of peristalsis, it closed. This probably resulted from the fact that its proximal end had been treated with talc and was not closing. Eight weeks after operation the untreated ends were marked by a firm nodule under the skin, and on the treated ends the stomas seemed stabilized. The open ends had clean everted lips of mucosa.

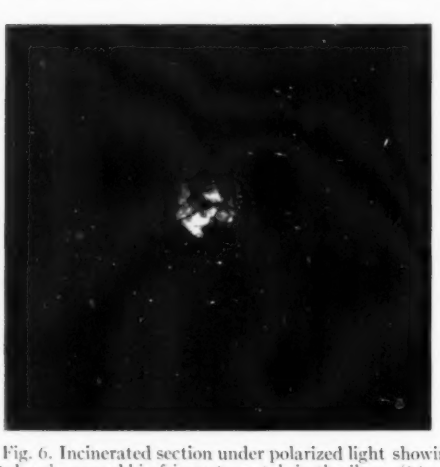

Fig. 6. Incinerated section under polarized light showing a tubercle around birefringent crystals in the ileum (×110; polarizer at total extinction).

Fig. 5. This lesion in the ileum on first study seemed to be noncaseous tuberculosis. The relation of the birefringent crystals to the reaction and their inclusion in foreign body giant cells and histiocytes suggest that they are the cause of the pathologic picture rather than the result of an inflammatory process. None of these crystals was visible in ordinary light (×48).

Four of the animals remained ill throughout the study and 2 regained their original activity. One animal was killed 96 days after operation and the others, 140 to 150 days after operation. At necropsy many adhesions to the sites of injection of talc were found. Two of the animals, both of which had been sick, had internal fistulas. These fistulas apparently had caused their chronic illness and loss of weight. One of them had multiple fistulas around the side-to-side anastomosis (Fig. 13). In 4 of the dogs the isolated ileal loops were the same size as the normal ileum but their walls were thickened. In 2 of the dogs the proximal loop, which had received an injection of the talc in the proximal end, was dilated and thickened to four times normal size. The distal ends of all the right loops had closed despite the fact that peristalsis ran in that direction. The closing of the distal ends of these right loops of intestine is probably the best evidence of the effect of talc in the wall of the intestine. Not only did it maintain patency in the end most likely to close but it permitted closure of the end most likely to remain open (Fig. 14). The factor that ordinarily keeps the distal end open is probably the mucus brought down by peristalsis. When proximal end was maintained patent by the talc in its wall, spontaneous closure of untreated distal end was permitted. The closed right distal and proximal limbs were represented by a fibrous cord in the abdominal wall. The mesentery was thickened and matted.

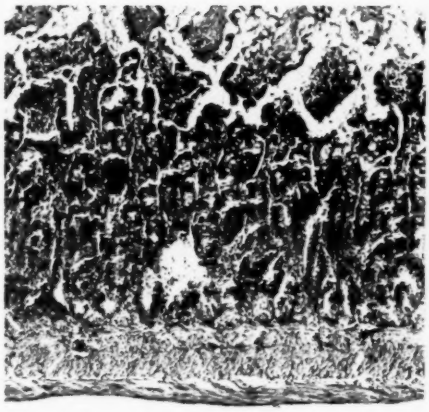

Fig. 7. Infiltration with leucocytes and lymphocytes of the terminal part of ileum of the rats fed talc.

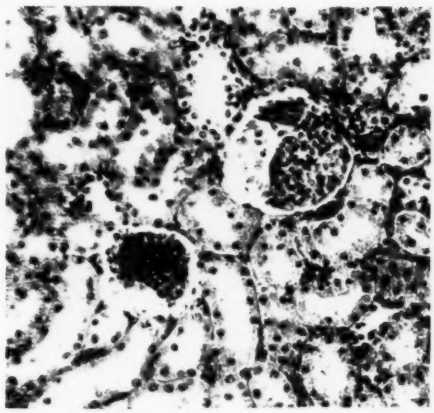

Fig. 8. The kidney of the rat showing early minimal glomerulitis with hemorrhage and slight infiltration of leucocytes (×176).

No talc nodules were seen grossly on the peritoneum of these dogs. In the regions in which the talc was placed, however, inflammatory granulation tissue was present. Examination of the other organs did not reveal any abnormalities. The anastomosis in the ileum in each animal was well healed and functioning although 2 animals showed the internal fistulas mentioned. Infection was general and operative trauma extensive.

Frozen sections were made of the organs and they were examined with the aid of polarized light. The mesentery and areas of lymphatic drainage for the sites of injection of talc were examined. No talc was found in these nodes or anywhere else but at the sites of injection or spilling of talc. With the small amounts of talc injected, there was little opportunity for its transport from the site of injection.

Although no visible talc was found to have been transported to the lymphatics of the mesentery there was definite evidence of the extension of the inflammatory reaction. The nodes of the mesentery showed marked hyperplasia with proliferation of the reticulo-endothelial cells of the sinuses such as is seen in mesenteric lymphadenitis. The spleen showed marked hyperplasia of the germinal centers with an increase of eosinophils. There were heavy bands of collagenous connective tissue along the blood vessels (Fig. 15). No birefringent talc was seen in the spleen or the liver. The hepatic lymph nodes were enlarged however.

The intestinal wall at the site of the injection of talc contained chronic granulomatous lesions. The villi were thickened and contained eosinophils, plasma cells, and histiocytes. There was hyperplasia of lymph follicles and muscle elements. The nerve tracts and ganglia in the intestinal wall near the site of injection were enormously hypertrophied and formed large masses. When larger talc particles were found (Fig. 16) in clusters, the lesion consisted of large numbers of foreign body giant cells surrounded by epithelioid leucocytes. The talc crystals distributed in the connective tissue tended to adlineate themselves with fibroblasts and collagen fibers. Many nodules of a

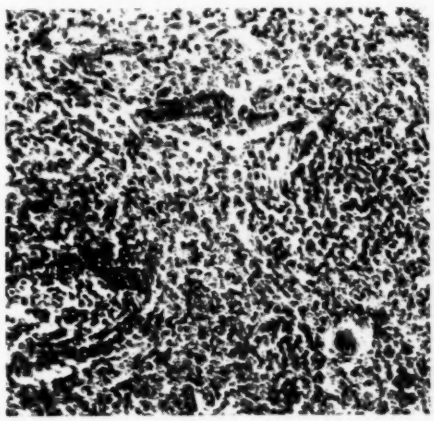

Fig. 9. Slight hyperplasia of the germinal centers in the spleen of a rat. There were areas of congestion, hemorrhage, and deposits of hemosiderin. Many small foreign body giant cells may be seen (×172).

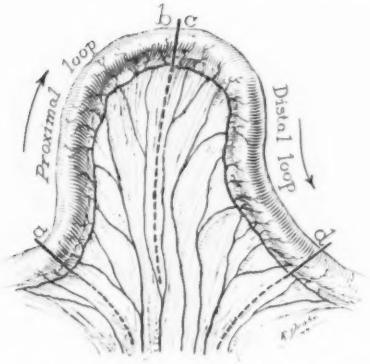

Fig. 10. Diagram showing the selection of the two loops from the terminal ileum and the manner by which the peristaltic direction was maintained so that the second loop would act as a control for the first loop; *a* and *c* are proximal ends; *b* and *d* distal ends.

cellular variety of fibrous tissue were present. These were particularly characteristic of the talc lesion in dogs (Fig. 17). Unlike the silicotic nodule, many fibroblasts were present and some capillaries crossed the nodules. There seemed to be little tendency for this type of fibrous tissue to close off its blood supply and little collagen and no hyalinization were noted. The connective tissue showed no obvious organization. On examination with polarized light no talc crystals were found in this region but when the section was incinerated small birefringent specks were found uniformly distributed throughout the connective tissue. The areas of desmoplasia were circumscribed by thin layers of collagenous connective tissue which in turn were surrounded by many lymphocytes. The connective tissue between the tunica muscularis and the muscularis mucosae was highly birefringent. This layer is birefringent in the normal intestine but the magnitude of birefringence was increased in these animals. Sections of ileum in the region injected with talc revealed a picture that resembled strikingly the picture found in regional enteritis.

As a result of this study on isolated loops of intestine together with information derived from the data considered thus far a possible explanation for the chronicity and progression of regional enteritis is as follows: It is known that some foreign bodies while producing a minor reaction themselves tend to sustain the inflammatory response to infection for long periods despite subsidence of the infection. Birefringent crystals have been

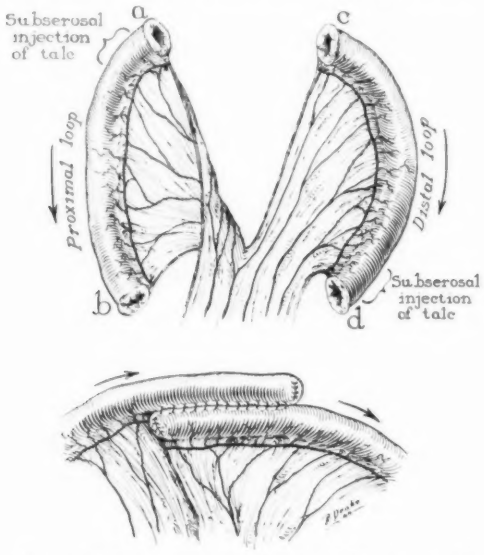

Fig. 11. Talc was injected subperitoneally at *a* and *d*. Control needle punctures were made at *b* and *c*. The loops were placed so that their peristaltic direction was caudad. Anastomosis in ileum is shown also.

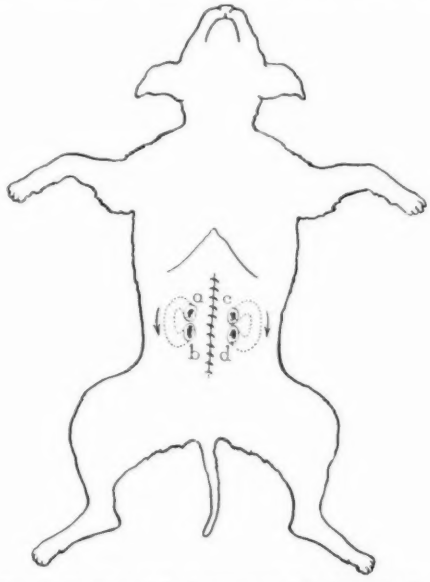

Fig. 12. Position of the four emerging limbs of the ileum on the dog's abdomen. Stomas at *a* and *d* were treated with talc and were the only ones to remain patent. Peristalsis was caudad in both loops and if talc had not been injected both *b* and *d* would have remained patent.

Fig. 13. Detail of the multiple internal fistulas developed in one animal by the introduction of talc into the peritoneal cavity. The dense adhesions have been dissected away.

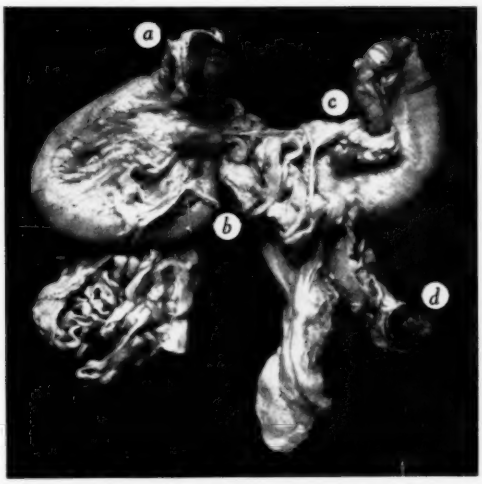

Fig. 14. Loops of isolated segments of ileum in one animal. The proximal limb (*a*) of the loop on the right of the animal (left in picture) and the distal limb (*d*) of the distal loop on the right of the animal were treated with talc. The stomas at these sites were patent. The other ends, *b* and *c*, end in fibrous cords. The thick mesentery and the mass of omentum that was dissected free from *a* and *d* should be noted.

found in some of the specimens of so-called non-caseous tuberculosis of the ileum and regional enteritis examined. In some of these cases the initial event may have been acute dysentery produced by a bacterial or virus infection with ulceration of the small intestine. The addition of a particulate foreign body to the granulation tissue in all probability would tend to prolong the inflammatory response. In due course of time the efficiency of the lymphatic disposal mechanism in the region would be decreased and the enteritis would have progressed.

The extreme hyperplasia of the nerve fibers and ganglion cells seen in the sections of ileum from the site of injection of talc in the intestine and in hyperplastic lesions of the ileum in regional enteritis probably is significant in the production of the intestinal dysfunction found in these conditions. It is usually assumed that the marked thickening of the intestinal wall in hyperplastic lesions of the ileum is due to increase of the connective tissue. In the specimens examined in this study of the effect of injection of talc on the intestine increase in the muscle elements was found to account for a large part of the thickening of the intestinal wall (Fig. 17). Shortening of the intestine and edema could account for some of this thickening if one is unwilling to assume the production of new fibers.

THE PATHOGENESIS OF TALC GRANULOMA

An attempt was made to make a systematized study of the granuloma produced by talc. The lesions described in this section were produced by the injection of a dilute aqueous suspension of talc into the subperitoneal tissues of the abdominal wall and into the intestine of dogs. From 3 to 4 milligrams of talc was used in each region in these experiments. The injections were made during the course of operations in which three transections and a side-to-side anastomosis of the ileum were performed with the animals under ether anesthesia by use of aseptic technique. The intestines were handled repeatedly. For control simple needle punctures were made in regions similar to those in which injections of talc were made. The appearance of the lesions 3 to 5, 19, 96 and 140 to 150 days after operation will be described after a few general comments have been made. Extreme variability in the reaction of the host to talc was a common finding in the study of talc granuloma. A similar variation of response to chrysotile asbestos, in different species and in different organs of the same species has been mentioned by Gardner (12). In the study on animals it was difficult to satisfy any hypothesis made concerning talc granuloma from study of the clinical material. Although the clinical material had indicated that talc readily produced a tubercle-like response in the peritoneum and ileum of the human being no lesions suggesting pseudotubercles were obtained by the injection of small amounts of talc into the dogs. It must be remembered however, that it is difficult to demonstrate tubercles in dogs even after injection of tubercle bacilli. Physicochem-

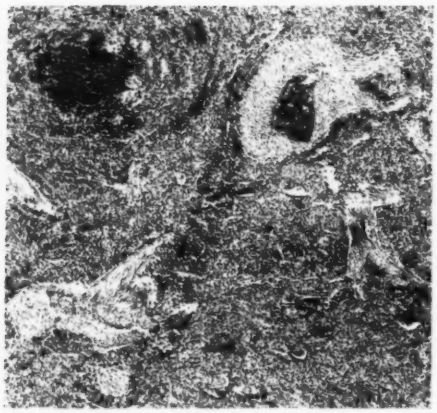

Fig. 15. Section of the spleen of an animal which had received subperitoneal injections of talc. Hyperplasia of the germinal centers is marked and the collagenous connective tissue is increased (×44).

ical factors in the foreign body dust and the local region of host tissue are subject to innumerable variations which control the type of reaction. The production of lesions morphologically resembling tubercles may require certain fixed conditions. Epithelioid cells may be derived from monocytes by the phagocytosis of colloidal or finely divided foreign material, with certain

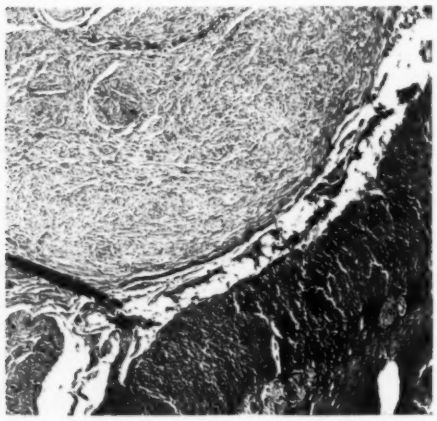

Fig. 17. A nodule of a rather cellular type of fibrous tissue produced in the ileum of the dog by the injection of talc crystals. Nerve fibers between the muscle coats are increased and the thickening of the muscular coats is probably brought about by a decrease in the length of the ileum which contributes to the thickening of the intestine. Regional enteritis shows a similar muscular hypertrophy (×62).

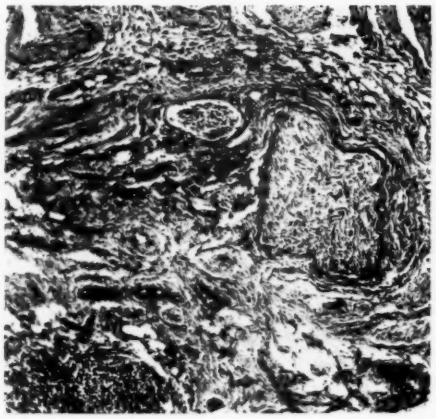

Fig. 16. Response of the ileum to larger crystals of talc that were injected. The crystals are enclosed by histiocytes. Hypertrophy of the nerves, thickening of the vessel walls, and moderate fibrosis should be noted. In the lower left corner there is an infiltration with lymphocytes (×53).

physicochemical characteristics, which does not destroy the cell. It is possible too that it requires a longer time than was allowed in this study, for the development of tubercles in dogs after the injection of talc. An active dry dust may be essential or the type of bacteria in the lesion may modify the lesion.

An early impression that trauma and infection played a leading part in the determination of the morphology of the talc lesion was not completely substantiated. In the same animal, adjacent regions showing extreme variation in the response were found. In some regions, the talc provoked a marked inflammatory response with many foreign body giant cells while in other regions it was found distributed in the connective tissue spaces simply engulfed in histiocytes with little surrounding reaction.

Lesions 3 to 5 days after injection. The immediate reaction to talc was necrosis of the cells in the region of the injection. At this time also bacterial infection was at its height. At the site of injection instead of the leucocytic response which bacteria alone would have produced, all cell outlines were lost and the field was strewn with chromatin débris. Small regions resembling caseous necrosis were found which were surrounded by polymorphonuclear leucocytes and an increased number of eosinophilic elements. An occasional crystal of talc was engulfed by histiocytes. The reaction was uniform at this time and not subject to the variation that was found at later periods. It rep

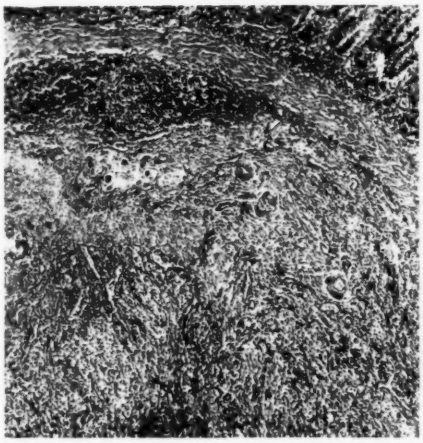

Fig. 18. Lesion in the ileum of the dog 19 days after the subperitoneal injection of talc. The response is inflammatory. Polymorphonuclear leucocytes, lymphocytes, and histiocytes are abundant (×47).

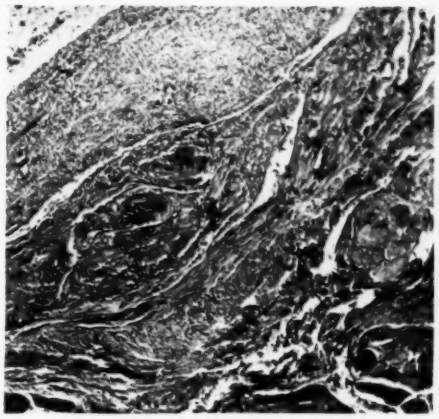

Fig. 19. Lesion produced by talc in the abdominal wall after 96 days. There is a proliferation of a cellular variety of connective tissue in bundles. The larger crystals in the center are engulfed by foreign body giant cells (×71).

resented the reaction to the more active talc molecules on the surface of the crystals and those already dispersed in the suspension fluid.

Lesions 19 days after injection. At this phase the nature of the response was determined by the size and distribution of the particles. Although particles of various sizes were distributed uniformly in the suspension at time of injection 19 days later the particles seemed to have been sorted by transportation.

The reaction around small particles up to 3 microns in diameter, about the size range of bacteria, was predominantly inflammatory (Fig. 18). Polymorphonuclear leucocytes, lymphocytes, and histiocytes were numerous. Eosinophils and some plasma cells were present. Lymphocytes were found in large masses. While fibroblasts were present there was no evidence of added fibrous tissue.

When the particles were moderate in size, approximately 3 to 12 microns in diameter, the crystals were engulfed by larger histiocytes. Little surrounding inflammatory response and no polymorphonuclear leucocytes were found. A large percentage of the crystals were parallel to the planes of the connective tissue found in the region. Similarly, the particles in histiocytes were usually situated in the long axis of the cell.

Larger particles of talc, measuring more than 12 microns in diameter, were engulfed by foreign body giant cells. When the particle was too large, only a portion was contained in the foreign body giant cell. There were no surrounding fibroblasts or leucocytes.

Lesions 96 days after injection. In the dog at this time the talc granuloma was characterized by peculiar desmoplasia and did not resemble granulomas found in man. The desmoplasia consisted of large nodular masses of a cellular type of fibrous tissue (Fig. 19). There was a limited amount of

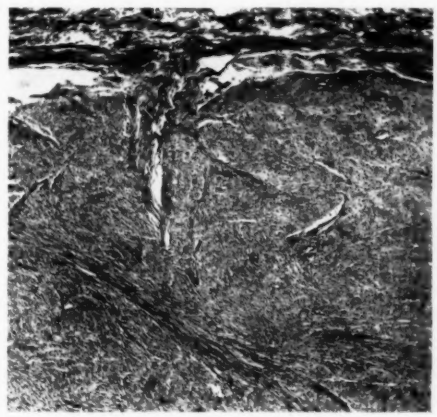

Fig. 20. Edge of a mature fibrous tissue nodule 140 to 150 days after injection of talc. The fibrous tissue is cellular and the capillaries are abundant. The surrounding connective tissue shows more fibrous and collagenous elements. This response occurs in dogs but in human beings a pseudotubercle forms (×44).

fibrillar tissue with little apparent arrangement. This fibrillar tissue was surrounded by a thin band of collagenous connective tissue. No visible talc crystals were seen in this nodule of loose connective tissue, but after incineration a dispersed form of talc crystals was found which was not made visible by polarized light in the fresh frozen section. After incineration these fine birefringent specks were easily visible. They were probably the bodies that were seen in brownian movement in the solubility studies.

Although no talc crystals were visible in fresh frozen sections in the nodular masses of loose connective tissue, talc crystals were visible in fresh frozen sections of tissues around the nodules. Large particles were engulfed by foreign body giant cells and the reaction about them was stationary. In the peritoneal adhesions examined, granulation tissue was found which was well vascularized and contained many particles of talc. Lymphocytes, histiocytes and eosinophils filled the regions between the capillary tufts and the fibroblasts were contained in a loose fibrillar tissue. Inflammation seemed to persist at this late date in these adhesions despite the fact that the inflammation in the peritoneal cavity in general had long since subsided. When nerves were found adjacent to the site of injection of the talc, particularly in the intestinal wall, hyperplasia of the nerve fibers and ganglion cells was seen.

Lesions 140 to 150 days after injection. The lesion had not changed from the one found earlier except for an increase in the collagenous connective tissue surrounding the loose fibrous nodules (Fig. 20). The loose fibrous tissue usually contained a few capillaries and occasionally larger vessels were seen crossing into the nodule.

Some of the characteristics of talc granuloma noted in this study of pathogenesis have suggested the use of talc from time to time when well vascularized new tissue is desired. It has been used to provide a parasitic blood supply for the heart and to create adhesions in the pleural space. It may be of value in producing a parasitic blood supply in cases of cirrhosis. In addition to these therapeutic uses of talc, its ability to maintain the patency of fistulas might be of value in establishing intentional biliary fistulas. There are many situations where a firm well vascularized tissue, which will not contract, is desired.

PRODUCTION OF GRANULOMAS BY FOREIGN BODIES WITH EMPHASIS ON TALC GRANULOMA

In view of the widespread use at operations of the dry glove technique which calls for the dusting with talc of gloves used by surgeons it is surprising that the injurious effects of talc are not seen more frequently. Evidence that the response of various individuals to foreign bodies differs greatly is encountered frequently. Many miners work for years in high concentrations of silica dust without the development of clinical silicosis whereas others show signs of silicosis. When symptoms do appear they usually are noted from 6 to 30 years after first exposure. Fats and oils are constantly being aspirated into the lungs; oil when it is a vehicle for some drug is injected frequently, radiopaque oil often is introduced for diagnostic purposes, and vaselin drains and paraffin have been used extensively for many purposes, yet a granuloma develops only occasionally. While the work on animals has revealed much less variation in the response to foreign bodies from animal to animal, even there the responses differ considerably. Concomitant infection and trauma seem to modify the individual response. The change in the *p*H of the tissue fluids (which are usually somewhat alkaline) produced by infection, may be a factor in altering the individual's response to foreign bodies.

When particulate insoluble foreign matter is introduced into the body, the initial reaction to the trauma of insertion is inflammatory. Substances which are initially toxic create such cellular proliferation and edema that the substances are shed by the formation of abscess or slough. Particulate substances which produce granulomas first invade the tissues insidiously. The presence of infection may modify events, so that the physicochemical properties of an almost innocuous foreign body can cause a foreign body reaction which in turn results in the pathologic changes of granuloma. The proliferation and phagocytic activity of the histiocytes increase. The purposeful aspect of this process is the provision of a barrier between the constantly changing tissue fluids and the foreign body. This barrier prevents the continuous leaching of the particle. The evidence for this assumption is the fact that if the particle has a jagged end, that end is surrounded first. The small particles are completely engulfed and the larger particles are isolated by many cells which ultimately fuse. In this phase of the process the toxic action of the fraction of the particle leached out within the engulfing cell determines the future course. If the toxic action is lethal, the field will be strewn with the pycnotic vestiges of phagocytic cells. Fresh phagocytes must take up the foreign body anew. If infection is still active phagocytic activity is less efficient; for when a histiocyte is performing one function, its ability to do others is reduced. The relative strength and

character of each of these factors determine whether the end-result is an abscess, a mass of lymphocytes, plasma cells or histiocytes, an epithelioid reaction with formation of so-called tubercles or fibrosis.

Tubercle bacilli have the peculiar property of acting as foreign bodies or inflammatory organisms at various times in the history of their residence in tissues. In one individual they produce a proliferative lesion and in another an exudative one. As time passes, if the activity of the tubercle bacilli is successfully slowed, an exudative lesion may change to a proliferative one by the increased production of limiting fibrous tissue. When silicosis and tuberculosis coexist, although fibrosis is a prominent feature at certain stages, a change in the physicochemical status of the tissue may permit acceleration of the growth of the tubercle bacilli. In addition, the fibrosis due to silica is so extensive that it interferes with the disposal mechanism of the tissue. Talc does not stimulate the production of fibrous tissue to the extent that silica does but the presence of infection and talc will cause minimal, nonprogressive fibrosis which provides a limiting or restricting barrier. In rare instances talc plus infection will produce a moderate degree of fibrosis. Lesions similar in many respects to talc granuloma result from crystals of cholesterol esters with the formation under suitable conditions of pseudotubercles. These lesions are frequently diagnosed as tuberculosis at first glance. The use of polarized light microscopy makes the cause obvious. A quiescent foreign body reaction may be activated by the addition of infection or trauma. When fatty tissues are involved, infection or trauma may cause the release of irritating free fatty acids and cholesterol esters. These in turn further aggravate the foreign body reaction.

In the silicotic nodule unbridled fibrosis may occur after which contraction of the fibrous tissue creates an avascular nodule. In this avascular nodule basket-weave laminations of collagen at first form discrete nodules. Added infection will induce a conglomeration of these nodules. Hyalinization, which is common as the mass of fibrous tissue increases in size, is accompanied by an increase in the natural silicate in the collagen. Tuberculous lesions show caseation, necrosis, and calcification. The pseudotubercles seen in so-called regional enteritis do not undergo these changes but pyogenic centered tubercles are seen in which the centers are filled with polymorphonuclear leucocytes. Talc, cholesterol esters, and some other foreign bodies produce pseudotubercles which, although they resemble early tubercles, do not show caseation, calcification, or pyogenic centers. The lesion produced by these foreign bodies seems to be arrested for long periods at the pseudotubercle phase with slight circumscribed fibrosis.

Great damage is caused by birefringent particles which are the same size as bacteria. They are engulfed rapidly by the phagocytes. Inert carbon particles will be engulfed but do not alter the activity of the phagocytes as there is no slow leaching of the particle. Therefore they may enter the blood stream with little injury to be stored innocuously in the storage depots of the bone marrow, spleen, liver, and lymph nodes. The action of silica particles is slow, allowing activity of the phagocytes long enough for them to carry the particles to a more dangerous site, the lymphatic channel. This Trojan-horse stratagem with early blockage of the lymph system explains the progressive nature of the silicotic process. Talc, however, seems to immobilize the phagocyte without destroying it and migration from the original site is limited. Hence most of the lesions produced by talc are circumscribed granulomas, which occasionally are activated after long quiescent periods by infection or trauma. Talc in some cases gets as far as the regional lymph nodes. Since migration of phagocytes containing talc is limited, plaques of talc have been found on the peritoneum where they had been placed accidentally by contact with a glove dusted with talc. There is just enough fibrosis to surround the granuloma. This lesion tends to remain stationary for a long time. The vascular supply to the small nodule is good, as there is slight tendency for proliferation of fibrous tissue which in contraction would diminish the blood supply. Asbestos ground to particles of from 1 to 3 microns in diameter causes lesions similar to the granulomas produced by talc.

COMMENT AND CONCLUSIONS

Evidence is presented to show that the tissue damage caused occasionally by talc is a heavy price to pay for the preservation of a pair of rubber gloves. Granulomatous lesions of the peritoneum, draining sinuses, scar nodules, and malfunctioning intestinal stomas were found at secondary operations. Polarized light microscopy was of great value in identifying talc crystals and in studying the pathogenesis of talc granuloma. It was our impression that talc granulomas would be recognized more frequently if there were greater use of polarized light microscopy and this study substantiated this hypothesis.

Talc implanted around intentionally created fistulas in dogs caused persistence of the fistulas.

A characteristic loose fibrous tissue lesion is produced by talc in dogs, whereas tissues of human beings react by forming pseudotubercles.

Lycopodium powder has been removed from use in the operating room. Talc also must go.[1] Foreign bodies of this type have no place at the operating table. Lubricating oil on instruments, petrolatum, and iodoform are injurious to some individuals. Even the lint left by pressure from dry gauze sponges may be found in adhesions following multiple operations. Synthetic materials which do not leave lint behind may be available presently. In some cases these minor factors cause unnecessary postoperative discomfort.

[1]Following the suggestion of Seelig, Verda, and Kidd we have been using potassium bitartrate at the Mayo Clinic with satisfaction in two operating rooms for 24 months. While this substance may not preserve rubber gloves as long as talc does, gloves are usually discarded because of perforations rather than wear. It is expected that a starch that can be autoclaved soon will be available which will be superior to talc.

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SECTION OF THE VAGUS NERVES TO THE STOMACH IN THE TREATMENT OF PEPTIC ULCER

THE important rôle of the nervous system in the production and maintenance of chronic ulcers in the stomach and duodenum has been suspected for many years. Many physicians have called attention to the high incidence of ulcers in individuals whose occupations subject them to continuous mental strain, worry and anxiety, and the tendency for exacerbations to occur during periods of emotional stress. The relatively high incidence of peptic ulcer in the armed services during the war may be, in part, due to similar causes. Direct evidence implicating the central nervous system was supplied by Cushing, who reported a greater occurrence of acute perforating ulcers of the stomach and duodenum in patients recovering from certain operations on the brain than mere coincidence could allow. These findings have been confirmed by others and indicate a definite hazard in neurologic surgery.

How can disturbances in the brain affect the stomach and produce a progressive perforating ulcer? While the gastrointestinal tract possesses a true local automatism, its tonus, motility, blood supply, and secretory activity are greatly modified by efferent impulses in the vagi and sympathetics. To a certain limited extent, these nerves exert antagonistic effects and the end-result represents a balance of opposing mechanisms. Excessive activity of the sympathetic fibers might, on theoretical grounds, lead to spasm of the cardia, atony of the stomach, spasm of the pylorus, and decrease in the tonus and motility of the intestines. No changes in the secretion of gastric juice would be expected but generalized or local vasoconstriction might result. The idea that peptic ulcer is due to local anemia of an area of the gastric mucosa as a result of embolism or vasospasm receives continued consideration. Cushing suggested that the ulcers observed by him might have such an origin. In recent years an attempt has been made in France to treat peptic ulcer by dividing the splanchnic nerves and excising the first two lumbar sympathetic ganglia. Relief of the ulcer distress was reported but the operation seems now to have been abandoned. The relief obtained could, of course, be due to interruption of sensory fibers conveying sensations of pain from the stomach. No convincing evidence has been presented that an excessive or abnormal activity of the sympathetic nervous system exists in ulcer patients, and the experimental evidence is for the most part against this point of view.

Excessive activity or hypertonus of the vagus efferent fibers might be expected to cause a relaxation of the cardia and pylorus, an increase in the motility and tonic constriction of the stomach, and an increase in the secretion of gastric juice. Gastric hypermotility in most ulcer patients has long been recognized and of late, evidence has accumulated indicating that an excessive continuous secretion of gastric juice occurs in the empty stomach in the absence of the usual stimulus of food. Both the hypermotility and hypersecretion are abolished by complete section of the vagus nerves to the stomach indicating that they are neurogenic in origin. The characteristic ulcer distress is also relieved and that this relief is not due to interruption of sensory fibers is indicated by the fact that the distress can be produced again by the instillation of a solution of hydrochloric acid into the stomach. Objective gastroscopic and x-ray evidence of the healing of large ulcer craters in the stomach, duodenum, and perhaps most of all, in gastrojejunal stomas after vagus section provides convincing evidence that this procedure corrects those factors that maintain chronicity and progression in these lesions. Since both motility and secretion are reduced, it is not possible to decide from this evidence alone which is the more important in the pathogenesis of the disease. It is in this connection that the data from the experimental laboratory are of decisive importance and the answer is clear. Pure undiluted gastric juice can digest away the normal mucosa of the stomach, duodenum, or jejunum and produce a typical progressive ulcer. Under normal conditions the gastric juice is diluted and buffered by food and the alkaline duodenal secretions. When an excessive secretion of gastric juice occurs in the empty stomach, the buffering effect of food is absent and the neutralizing capacity of the duodenal secretions is overcome. The gastric content then approaches pure gastric juice in free acidity and pepsin concentration and that area of the gastric or duodenal mucosa which is most exposed or least resistant first succumbs. An ulcer forms, progresses, and persists so long as exposure to relatively pure gastric juice continues. Therapy accordingly should be directed toward reducing the volume and acidity of the night secretion. The finding that the excessive continuous secretion in the fasting stomach of ulcer patients is neurogenic in origin constitutes the physiological basis for vagus section as a method of treatment. At the present writing, 90 patients have been operated upon by this method in this clinic. Keith Grimson at Duke University, Francis Moore in Boston and Dixon and Clagett at the Mayo Clinic have also reported similar series. So far, there appears to be general agreement concerning the immediate and long continued relief of ulcer distress. For the most part, the period of observation has been too short to permit a final evaluation of the method and the question of ultimate regeneration of the divided vagi remains undecided. The first 12 patients operated upon here a little over three years ago are still well, take no medication, and are under no dietary restrictions. The night secretion of gastric juice is still within the normal range and tests of gastric secretion by the sham meal and insulin hypoglycemia show that regeneration of secretory fibers in the vagi has not yet occurred.

These findings provide strong support to the concept of ulcer as a psychosomatic disease, this term being used merely to indicate that emotions and mental activity of certain types play a dominant rôle in the pathogenesis. The central nervous system disturbance causes ulcers by producing a hypertonus in the secretory and motor fibers

in the vagus nerves. While the severing of these nerves prevents nervous tensions of various kinds from affecting the stomach, it cannot be considered the final answer to the ulcer problem. Perhaps this may lie in adjusting the individual to his work and environment so that these tensions do not arise. The possibilities of psychotherapy in ulcer ought to be re-explored, and the volume and acidity of the continuous night secretion of gastric juice used as an objective quantitative measure of the effect of the treatment. Such data would probably be more impressive to the surgeon than the most subtle manipulation of a terminology he never fully understands.

LESTER R. DRAGSTEDT.

BENIGN STRICTURES OF THE BILE DUCT

STRICTURE of the common or hepatic bile duct most often follows clamping, ligation or excision of the duct during cholecystectomy. Sir James Walton has said "Every removal of a gall bladder, easy though it may seem, is fraught with very great danger, and one small error may convert a patient with a mild disability into one in immediate danger of death or of prolonged misery, and many operations, which at best may only give an incomplete life." The common duct will not be injured if it is clearly seen. The first necessity is adequate exposure with accurate definition of the junction of the hepatic, cystic, and common ducts before anything is clamped or cut. If this rule is followed, most of the hazards are eliminated. Injury occurs with inadequate exposure, inflammation or impaction of stones that shorten the cystic duct, strong traction on the gall bladder that tents up the common duct, anatomic abnormalities that confuse the relations, and blind efforts to control bleeding.

If the surgeon discovers a damaged or severed common bile duct, it should be repaired immediately for it is never easier to do later. The two ends of a divided duct should be united by end-to-end anastomosis. If a T-tube is used, the vertical limb should not come out through the suture line but rather above or below it. A duct that has been crushed by a clamp should be allowed to heal over a tube. If it is badly macerated, the devitalized tissue may be excised and an end-to-end anastomosis done.

The end-result of unrepaired common duct injury is biliary fistula or stricture with its devastating sequelæ. Small strictures are not so serious for they may often be successfully treated by plastic repair or by excision and end-to-end anastomosis. The real problem concerns those who have extensive stricture or loss of the duct, often complicated by repeated, fruitless attempts at repair and usually associated with anemia, hypoproteinemia, infection, and liver damage. These may tax the fortitude, patience and ingenuity of those who seek to repair them. No single method is applicable to all cases. In general, two methods of attack have been used; either anastomosis of the duct to the intestine or reconstruction of the duct. Of the former, anastomosis of the duct to the duodenum has been used most frequently but only 23 per cent have a successful end-result (Eliot). The Roux Y type of choledochojejunostomy, popularized by Whipple, is a more physiological intestinal anastomosis since the antiperistaltic loop of jejunum prevents reflux of intestinal contents into the biliary tract.

It appears desirable, whenever possible, to restore the normal anatomical arrangement of the part for few surgical procedures improve on nature. For this reason, even with extensive loss or stricture, efforts should be made to reunite what remains of the duct. Such a

union may be possible only with tension on the suture line which permits reformation of the stricture. To prevent stricture the duct should heal over a tube which holds it open during repair. Dissatisfaction with the tissue irritation and fibrosis caused by rubber led to the use of vitallium for this purpose. Vitallium was selected because of its lack of tissue reaction, its smooth surface which did not attract concretions and its high tensile strength which permitted a thin wall with maximum lumen. Tantalum also has these characteristics and is more malleable but it cannot be welded, so no anchoring flange can be attached to it. Plastics were discarded because most of them are tissue irritants. Vitallium tubes have the disadvantage of being so hard that they cannot be altered, at the time of operation, to meet the needs of every situation nor is it possible for them to be removed except by an operative procedure.

Recently, 226 cases of the use of vitallium tubes were collected from a group of surgeons and the results studied. The outcome was satisfactory in 80 per cent of the cases when the tube was used for the reconstruction of the duct. Plugging of the tube occurred in 11 per cent and was the commonest cause of failure. This plugging may be diminished by using bile salts postoperatively but metabolic changes and infection make it difficult to eliminate occlusion of the tube completely. Anastomosis of the duct to the duodenum over a vitallium tube gave 58 per cent satisfactory results. The tube passed into the intestine in 38 per cent of the cases. This sequela is to be expected for no amount of anchoring will prevent the loosening of the tube. The results of Whipple's Roux Y anastomosis are still better for it is a more physiological operation.

The results enumerated are a real improvement over past experience. They are not perfect and one may question if perfection can be attained under the difficult circumstances encountered in these cases. The most profitable direction for efforts in the future would be the training of surgeons to avoid injury to the bile ducts. Until this is realized the search must continue for improvement in our present techniques and methods. HERMAN PEARSE

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

NO one who is interested in the surgery of the upper extremity will fail to secure stimulating and helpful ideas from a careful reading of Dr. Steindler's *Traumatic Deformities and Disabilities of the Upper Extremity.*[1] In this volume of almost 500 pages after a general discussion of traumatic disabilities of the upper extremity the author considers in turn disabilities of the shoulder girdle and arm (140 pages), of the elbow joint (90 pages), of the forearm and wrist (100 pages), and of the hand and fingers (75 pages).

One's first impression is of the serious and thoughtful consideration the author brings to bear on the various problems he discusses. For example (page 4), "An identical fracture of the radius may result in one case in a skeletal disalignment without any secondary impairment of the soft structures, in another case there may be no skeletal disalignment but a great deal of involvement of the soft tissues; in a third case a traumatic arthritis will develop, and in a fourth case Sudeck's atrophy on angioneurotic basis may be the principal factor of the disability." It is easy to recognize the obvious factors involved in a given problem. Steindler constantly emphasizes the importance of searching for and recognizing all the pathological factors involved if one is to solve the problem successfully.

The second impression is of the frank and objective manner in which the author attempts to evaluate the results he has obtained from the various procedures he has carried out. One must feel a very real respect and admiration for workers who attempt to evaluate the final results of the methods they have utilized, and who state them honestly. It is easier to portray only the good results and omit the failures and the reasons for their occurrence.

The section on the shoulder girdle and arm is the longest and most complete. After emphasizing the vulnerability of the shoulder girdle because of its connection to the thorax almost solely by muscle masses the author discusses in turn the acromioclavicular articulation and its dislocation, the sternoclavicular articulation and the shoulder joint and its dislocations. The various procedures advocated for the correction of recurrent dislocation are carefully described and the indications for each pointed out. The Nicola operation and the Henderson operation have proved most successful and have been used in the majority of cases.

Fractures of the clavicle followed by nonunion, fractures of the scapula, of the upper end of the humerus—neck and tuberosities, traumatic arthritis of the shoulder joint, and fractures of the humeral shaft are discussed with unusual completeness. In reading the illustrative case reports one is constantly impressed with the variety and extent of the author's experience, and particularly with the complicated and difficult cases of bone injury—of scapula, humerus, elbow, and forearm—that have come under his care.

Consideration of injuries of the musculospiral nerve, axillary nerve, and of the brachial plexus associated with fractures and dislocations of the humerus, rupture of supraspinatus and biceps tendons, and contractures due to burns completes the section which is devoted to conditions of the shoulder girdle and arm.

Traumatic disabilities of the elbow joint, of the forearm and wrist and of the hand and fingers are taken up in turn with somewhat diminishing emphasis. The complications resulting from fractures and dislocations about the elbow joint, flexion and extension block, nerve injuries and Volkmann's ischemic contracture are discussed in helpful detail. Here again one is impressed with the difficulty and complexity of many of the cases presented, and the conservative attitude which characterizes the author's approach to their treatment. In the treatment of Volkmann's contracture the best results have been obtained by conservative treatment, and, in cases of severe deformity, when conservative treatment has failed, by resection of a part of the carpus and shortening of the extensor tendons. The author believes that there are few indications for detaching the flexor tendons from the medial epicondyle or for shortening of the bones of the forearm.

Nonunion following fracture of both bones of the forearm, radioulnar synostosis, fracture of the ulna with dislocation of the head of the radius, complicated fractures of the lower end of the radius, fractures of the scaphoid, dislocation of the semilunar, Kienbock's disease and Sudeck's atrophy, tendon transference in cases of irreparable musculospiral injury—are all considered in turn, and the treatment illustrated with case reports, diagrams and x-ray films. One can think of none of the many conditions arising from injury of forearm and wrist which has been omitted from consideration.

In the disabilities affecting the hand the chief emphasis has been placed on fractures and dislocations of metacarpals and phalanges and on tendon and nerve injuries. The author's operation and Bunnell's operation for thenar palsy are carefully described and illustrated. Certain procedures concerning which the surgeon with limited experience might

[1] THE TRAUMATIC DEFORMITIES AND DISABILITIES OF THE UPPER EXTREMITY. By Arthur Steindler, M.D., F.A.C.S. In collaboration with John Louis Marxer, M.D. Springfield, Ill.: Charles C Thomas, 1946.

well be in doubt, for example, cup arthroplasty at an interphalangeal joint, and artificial methods for reforming tendon sheaths, are described, but the reader is left in doubt as to the author's opinion as to their value and usefulness.

Throughout the entire volume diagrams, photographs, and reproductions of x-ray films help to illustrate the test. The drawings are not always easy to interpret; sometimes they are almost "impressionistic" (Figs. 386, 387). In some instances the addition of legends would help to avoid confusion in their interpretation.

It is obvious that in reviewing a volume which touches upon so many conditions and covers such a wide field one can do little more than point out its purpose and scope. It deserves high praise, and constitutes a record of achievement that will serve both as an example and a highly useful guide to every surgeon confronted with similar problems.

SUMNER L. KOCH.

THE volume entitled *Medical Services by Government*[1] by Dr. Bernhard J. Stern, comprising 208 pages, is published by The Commonwealth Fund and is one of the studies of the New York Academy of Medicine Committee on Medicine and the Changing Order. It presents in historical perspective a comprehensive summary of the complex and expanding field of government medical services, federal, state, and local. It should be of interest to those who like to discuss the subject of state medicine which is such a popular pastime at medical meetings nowadays because it contains a great wealth of factual material bearing on this subject. From this book one gets the impression that the establishment of the doctrine of government responsibility for medical care is a *fait accompli;* that all that is left is a matter of methods and mechanics of organization. C. T. OLSON.

[1]MEDICAL SERVICES BY GOVERNMENT; LOCAL, STATE AND FEDERAL. By Bernhard J. Stern, Ph.D. New York: The Commonwealth Fund, 1946.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

DIAGNOSTIC EXAMINATION OF THE EYE. By Conrad Berens, M.D., F.A.C.S., and Joshua Zuckerman, M.D., C.M., F.A.C.S. Philadelphia, London, Montreal: J. B. Lippincott Co., 1946.

PROCEEDINGS CONFERENCE ON DIAGNOSIS IN STERILITY. Sponsored by the National Committee on Maternal Health, January 26–27, 1945, New York City. Edited by Earl T. Enge. Springfield: Charles C Thomas, 1946.

CIRUGIA ESTÈTICA. By Dr. Ramon Palacio Posse. Buenos Aires: Libreria Y Editorial "El Ateneo," 1945.

FISTULAS ANORRECTALES: FISTULECTOMÍA SÍN SECCIÓN DE ESFÍNTERES. By Juan Antonio Garat. Buenos Aires: Libreria Vazquez Editorial, 1946.

SEMIOLOGIA OBSTETRICA. By Juan Leon. Buenos Aires: Libreria Cientifica y Literaria "El Ateneo," 1946.

LESÕES DO RECORRENTE. By Mariano A. De Andrade. Rio de Janeiro: Rodrigues & C., 1945.

PHYSICAL EXAMINATIONS OF SELECTIVE SERVICE REGISTRANTS. An Analysis of Reports for the Continental United States and Each State, April 1942—December 1943. Washington, D.C.: National Headquarters Selective Service System, November 1, 1944.

LEHRBUCH DER GYNÄKOLOGIE. Prof. Dr. Hans Guggisberg. Basel: S. Karger, 1946.

THE NORMAL ENCEPHALOGRAM. By Leo M. Davidoff, M.D., and Cornelius G. Dyke, M.D. 2nd rev. ed. Philadelphia: Lea & Febiger, 1946.

SEX, MARRIAGE AND FAMILY. By Thurman B. Rice, A.M., M.D. Philadelphia and New York: J. B. Lippincott Co., 1946.

THE PRINCIPLES OF NEUROLOGICAL SURGERY. By Loyal Davis, M.S., M.D., Ph.D., D.Sc., (Hon.). 3rd rev. ed. Philadelphia: Lea & Febiger, 1946.

ILLUSTRATIONS OF REGIONAL ANATOMY. By E. B. Jamieson, M.D. Section 1—Central Nervous System. Section 2—Head and Neck. Section 3—Abdomen. Section 4—Pelvis. Section 5—Thorax. Section 6—Upper Limb. Section 7—Lower Limb. 6th ed. Edinburgh: E. & S. Livingstone, 1946.

CLINICAL CONGRESS OF AMERICAN COLLEGE OF SURGEONS

W. EDWARD GALLIE, TORONTO, *President*
IRVIN ABELL, LOUISVILLE, *President-Elect*

Committee on Arrangements
THOMAS E. JONES, *Chairman;* JOHN W. HOLLOWAY, *Secretary*

PRELIMINARY PROGRAM FOR THE 1946 CLINICAL CONGRESS IN CLEVELAND—DECEMBER 16 TO 20

UNDER the direction of the Board of Regents, plans are proceeding for the thirty-second annual Clinical Congress, to be held in Cleveland, December 16 to 20, with headquarters at the Cleveland Public Auditorium and at the Statler and Cleveland hotels. The Auditorium is an impressive, well designed building. Its Arena, Music Hall, Little Theater, Ballroom, and other large halls, provide exceptional facilities, so that most of the activities of the Congress, except the clinical program, will be housed in it.

The program of the Congress in general will be focused upon the many medical and surgical problems connected with important postwar advances, including rehabilitation of veterans.

CLINICAL PROGRAM

The surgeons of Cleveland have appointed an executive committee, with Dr. Thomas E. Jones as chairman, and Dr. John W. Holloway as secretary. The committee with the aid of a representative in each hospital is now preparing a preliminary clinical program. This will consist of operative and nonoperative clinics and demonstrations that will provide a comprehensive showing of their clinical activities in all departments of surgery at Western Reserve University School of Medicine and the approved hospitals of Cleveland. Under the leadership of this committee, a varied program of interest to general surgeons and all surgical specialists is assured for the 1946 Congress.

GENERAL ASSEMBLY

The Clinical Congress will open with a general assembly in the Music Hall of the Cleveland Public Auditorium at 10:00 o'clock on Monday morning. Dr. W. Edward Gallie, President of the College, will preside at this meeting which will be the opening session of the twenty-fifth annual Hospital Standardization Conference. Doctor Gallie will discuss the Hospital Standardization program of the College, especially as it affects the hospitals of Canada. Dr. Irvin Abell, Chairman of the Board of Regents, will then report on the progress of the 1946 Hospital Standardization

EXECUTIVE COMMITTEE

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HOSPITALS AND REPRESENTATIVES

City Hospital	JOHN HENRY LAZZARI
Cleveland Clinic	ROBERT S. DINSMORE
Evangelical Deaconess	OLIVER A. WEBER
Fairview Park Hospital	W. E. SMITH
Glenville Hospital	JACOB E. TUCKERMAN
Grace Hospital	L. J. STERNICKI
Huron Road Hospital	HENRY W. BROWN
Lakeside Hospital	FREDERICK R. MAUTZ
Lakewood Hospital	C. LEE GRABER
Lutheran Hospital	FRANK S. GIBSON
Maternity Hospital	DONALD FAULKNER
Mt. Sinai Hospital	RUDOLPH REICH
Polyclinic Hospital	HENRY SCHLINK
St. Alexis Hospital	JOHN F. CORRIGAN
St. Ann's Hospital	E. P. MONAGHAN
St. John's Hospital	FARRELL T. GALLAGHER
St. Luke's Hospital	DONALD GLOVER
St. Vincent's Charity	OLIVER A. WEBER
U. S. Marine Hospital	MARK E. MEYERS
Woman's Hospital	ERNEST COX
Veterans Hospital	DR. PARTINGTON *Chief Surgeon*

survey, final results of which, including the Approved Lists of hospitals, cancer clinics, and approved hospitals for graduate training in surgery, will be announced at the end of the year.

The remainder of the Monday morning session will be devoted to talks by medical and hospital authorities on advances in medicine and surgery as they affect the postwar hospital, with particular consideration of their relation to the Hospital Standardization program.

PRESIDENTIAL MEETING

The Presidential Meeting will be held on Monday evening in the Music Hall of the Auditorium. The officers, regents, and honorary guests will participate in the processional. Dr. W. Edward Gallie, President of the College, will preside. The address of welcome will be given by Dr. Thomas E. Jones, Chairman of the Executive Committee, foreign guests will be introduced, and Doctor Gallie will deliver the Presidential Address. An inaugural ceremony will be held for the incoming officers: President, Dr. Irvin Abell of Louisville; First Vice-President, Dr. Leland S. McKittrick of Boston; Second Vice-President, Dr. F. Phinizy Calhoun of Atlanta.

The first Martin Memorial Lecture will be a feature of the Presidential Meeting this year. Dr. Edward D. Churchill of Boston has accepted the invitation to give this lecture. The lectureship was established upon motion of the Board of Regents at its midyear meeting on April 1, as a memorial to both Dr. Franklin H. Martin and Mrs. Martin. The founder of the College and of SURGERY, GYNECOLOGY AND OBSTETRICS, was joined by his wife in making the College the beneficiary at their deaths of the Journal, together with its physical plant operated by the Surgical Publishing Company of Chicago, of which they were the owners. Doctor Martin died in 1935 and Mrs. Martin in 1945.

The Martin Memorial Lecture, to be given annually during the Clinical Congress, and dealing with a scientific subject of the author's choosing, supplants the Annual Oration in Surgery.

CONVOCATION

The Convocation will be held on Friday evening. It will open with a processional of officers, regents, governors, and initiates. The President, Dr. Irvin Abell, will preside, confer the honorary fellowships, and present the candidates for fellowship.

An Assembly of Initiates will be held at 10:30 on Friday morning in order to instruct them in the Convocation procedure and other matters. On this occasion the initiates will sign the fellowship roll.

Several hundred surgeons who have been received into fellowship *in absentia* during the war years in which no Convocation was held, will be added to the number of initiates for the current year who will be present to participate in the initiation ceremonies. The Convocation and in fact the meetings throughout the Congress will be occasions for reunion with many Fellows who have recently returned from service with the military forces.

SCIENTIFIC SESSIONS

General Surgery

Eminent surgeons and specialists, recognized as authorities in their fields, will address the scientific sessions, to be held on Tuesday, Wednesday, and Thursday evenings. These will be conducted as symposia, and the subjects for the three nights will be as follows: Tuesday, "Care of the Patient Before and After Operation"; Wednesday, "Venous Thrombosis and Prevention of Pulmonary Embolism"; and Thursday, "Antibiotic and Chemotherapeutic Agents in Surgery." The annual Fracture Oration will be included in the Wednesday evening program.

Two major panel discussions will be held every afternoon except Thursday when the first panel will be omitted because of the annual meeting of the Fellows.

A symposium on fractures and other traumas will be held on Tuesday afternoon, and a symposium on cancer on Wednesday.

Concurrent panel discussions are also planned on Friday afternoon for each of the following specialties: plastic surgery, thoracic surgery, urology, neurological surgery, orthopedics, and obstetrics. Outlines of the programs are published in succeeding pages.

Ophthalmology and Otorhinolaryngology

Ophthalmology panel discussions will be held Tuesday, Wednesday, and Thursday mornings at 11:00 o'clock on, respectively, "Retinal Detachment," "Glaucoma," and "Keratoplasty." On Tuesday evening at 8:00 o'clock there will be a symposium on "Orbital Reconstruction Including Prosthesis." On Thursday evening a symposium is planned on "Recent Advances in Ophthalmology," with presentation of the following subjects: "Surgical Applied Anatomy in Eye Surgery"; "Visual Field Defects Due to Head Injuries"; "The Management of Non-Magnetic Intraocular Foreign Bodies"; and "The Treatment of Strabismus in Children."

Otorhinolaryngology panel discussions will be held Tuesday, Wednesday, and Thursday mornings at 11:00 o'clock on, respectively, "Treatment of Meniere's Disease," "Osteomyelitis of the Skull," and "Rehabilitation of the War Deafened." On Tuesday evening at 8:00 o'clock there will be a symposium on "Treatment of Deafness" and on Thursday evening a symposium on "Surgery of the Nasal Accessory Sinuses."

Of interest to ophthalmologists, otorhinolaryngologists, and other surgeons will be a symposium to be held on Wednesday evening at 8:00 o'clock on "Plastic Surgery of the Head and Neck."

FORUMS ON FUNDAMENTAL SURGICAL PROBLEMS

The Forums on Fundamental Surgical Problems will be conducted on Tuesday, Wednesday, Thursday, and Friday mornings. Included in them will be brief reports of original clinical and experimental observations relating to the broad aspects of surgery and the surgical specialties. No prepared discussions of the reports are planned, but questions and comments will be invited. Especially keen interest is expected in these sessions this year because of the accumulation of the results of 5 years of work since the last Clinical Congress. Dr. Owen H. Wangensteen of Minneapolis, chairman of the committee which is planning the program, is working toward representation of as many as possible of the various university departments of surgery in this presentation of clinical and experimental research work.

The enlistment of the interest of young men who are doing original work, through the forums, is one of the most beneficial results of these sessions which are now considered to be an indispensable feature of every Clinical Congress.

HOSPITAL CONFERENCE

The opening General Assembly on Monday morning in which both surgeons and hospital representatives will participate has been mentioned previously. The afternoon conference on Monday will be concentrated upon current problems and the outlook for the future in nursing service.

The Tuesday morning conference will be centered upon discussion of management techniques as they affect standards of hospital service. The Tuesday afternoon session will consist of a panel discussion of training and other personnel problems in specific fields, such as dietary, laboratory, x-ray, pharmacy, physical and occupational therapy, medical records, medical social service, and employe relations in small hospitals.

The Wednesday morning conference will have as its main theme the importance of assuring high standards of care to the community and patients through providing in the general hospital facilities for all types of illness. The subject will be discussed from the standpoint of psychiatric, tuberculous, cancer, chronically ill, and convalescent patients. The Wednesday afternoon meeting will be a panel discussion on the responsibility of the administrative staff in dealing with common emergency procedures.

The Thursday morning conference will revolve around the physical plant of the hospital and the importance of improvement and modernization in raising standards of care of the patient. New mechanical and technical developments will be presented. The afternoon conference will discuss the hospital as the health center of the community, with consideration of the effects of this concept upon hospital public relations and upon the progress of preventive medicine and public health.

An evening conference will be held at 7:30 o'clock on Tuesday. This will be devoted to discussion of the responsibilities of trustees, and members of governing boards will be especially invited to attend and to participate. A conference will be held on Wednesday evening also. This will be a round table conference on responsibilities of hospital administrators, and the preparation which is necessary to enable them to cope successfully with the wide range of administrative problems. The discussion of these problems will interest all hospital personnel.

ANNUAL MEETING OF FELLOWS

The annual meeting of the Governors and Fellows will be held on Thursday afternoon at 1:45. There will be election of officers and governors. The annual meeting affords the Fellows of the College an opportunity to hear reports of officials on the work of the organization, and to learn how it has not only raised the professional and ethical standards of surgery, but has also promoted good hospitalization and general improvement in the practice of medicine in the United States and Canada. Each Fellow has a personal part in this work and may extend the influence of the College materially in his local community. Hospital Standardization alone offers him unlimited opportunity to provide better medical care for his patients in the hospital in which he works through continuous progress in applying the principles of the Standard which insure the best care of the patient.

Every Fellow will want to attend this important meeting, at which reports will be presented on financial affairs; Hospital Standardization; Graduate Training in Surgery; Medical Motion Pic-

tures; Publications; Public Relations; Library and Literary Research; the work of the state and provincial credentials committees, committees on applicants, and the Committee on History Reviews; Sectional Meetings, 1946; and the Department of Clinical Research, including cancer clinics, Medical Service in Industry, the Committee on Cancer, and the Committee on Fractures and other Traumas. Dr. Abell will report on administration of the College, staff changes, and retirements, and Dr. Arthur W. Allen, Vice-Chairman of the Board of Regents will discuss "Fellowships, Obligations and Opportunities."

STATE AND PROVINCIAL EXECUTIVE, CREDENTIALS AND JUDICIARY COMMITTEES

On Wednesday morning from 9:00 to 12:00 o'clock the State and Provincial Executive, Credentials, and Judiciary committees will meet to discuss their respective activities.

MEDICAL MOTION PICTURES

The latest available films showing surgical procedures and related subjects will be shown in the medical motion picture exhibits which will be held daily in the Little Theatre. These are a much appreciated feature of the Clinical Congress. Despite the decrease in production of such films during the war period, a surprising number of new pictures on varied subjects are being received by the American College of Surgeons for review.

Both sound and silent, standard and color films will be shown, all of which have been approved by the Committee on Medical Motion Pictures.

TECHNICAL AND SCIENTIFIC EXHIBITION

The technical exhibit, together with the registration and clinic ticket bureaus, will be held in the Cleveland Public Auditorium. Leading manufacturers of surgical instruments, x-ray apparatus, sterilizers, operating room lights, ligatures, dressings, hospital apparatus and supplies of all kinds, pharmaceuticals, and publishers of medical books will be represented in the exhibition. The technical exhibits will demonstrate many of the newer features learned from our experience in the war. Surgeons and hospital people will have opportunities to inspect the latest products of industries which help to improve their service.

ADVANCE REGISTRATION

The hospitals of Cleveland afford accommodations for a considerable number of visiting surgeons. However, in order to insure against overcrowding, attendance at the Congress will be limited to the number that can be comfortably accommodated at the meetings and also by accommodations in the hotels. It is therefore expected that surgeons who wish to attend the Congress will register in advance.

Fellows of the College whose dues are paid to December 31, 1945, initiates of the classes of 1942, through 1946, and Fellows in military service will not be required to pay a registration fee for the Clinical Congress in Cleveland. Checks that have already been sent for the New York Congress are being returned. For endorsed junior candidates the fee is $5.00. Surgeons, not Fellows, who attend as invited guests of the College, will pay a registration fee of $10.00.

CLEVELAND HOTELS AND THEIR RATES

Although the hotel situation in Cleveland seems more favorable than in many other cities, it is nevertheless essential to make reservations as far in advance as possible. Following is a list of the principal hotels:

	No. of Rooms	Rates
The Alcazar, Surrey and Derbyshire Roads	200	$3.00 up
Hotel Allerton, E. 13th St. & Chester Ave.	600	2.65 up
Hotel Auditorium, E. 6th & St. Clair Ave.	300	2.00 up
Belmont Hotel, Euclid Ave. at E. 40th St.	200	2.00 up
Hotel Bolton Square, Carnegie at E. 89th St.	300	2.50 up
Carter Hotel, 1012 Prospect Ave.	600	4.00 up
Hotel Cleveland, Public Sq. & Superior Ave.	1,000	3.00 up
Fenway Hall Hotel, Euclid Ave. at Univ. Circle	400	3.00 up
The Hollenden, Superior Ave. at E. 6th St.	1,000	3.00 up
Lake Shore Hotel, 12506 Edgewater Dr.	450	3.50 up
New Amsterdam Hotel, Euclid Ave. at E. 22nd St.	300	2.00 up
Hotel Olmsted, E. 9th St. & Superior Ave.	250	3.00 up
Park Lane Villa, E. 105th & Park Lane Ave.	400	3.00 up
Sovereign Hotel, 1575 E. Blvd.	300	2.50 up
Hotel Statler, Euclid Ave. at E. 12th St.	1,000	3.00 up
Tudor Arms Hotel, Carnegie at E. 107th St.	200	3.50 up
Wade Park Manor, E. 107th & Park Lane	400	3.50 up
The Westlake, Blount St., Rocky River	400	3.00 up

CLINICAL CONGRESS PROGRAM IN BRIEF

UNLESS OTHERWISE DESIGNATED, THE MEETING ROOMS LISTED ARE IN THE CLEVELAND AUDITORIUM

Monday

10:00 General Assembly for Surgeons and Hospital Representatives, Music Hall
1:30–3:00 Panel Discussion, Music Hall
2:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
2:00 Hospital Conference, Ballroom
1:00 Surgical Film Exhibition (General), Little Theatre
3:30–5:00 Panel Discussion, Music Hall
8:00 Presidential Meeting, Music Hall

Tuesday

9:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
10:00 Hospital Conference, Ballroom
9:30 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
9:30–12:00 Forum on Fundamental Surgical Problems, Music Hall
10:00 Surgical Film Exhibition (General), Little Theatre
11:00 Panel Discussions
Ophthalmology, South Hall A
Otorhinolaryngology, South Hall B
1:30–3:00 Panel Discussion, Music Hall
2:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
2:00 Hospital Conference, Club Room B
2:00 Symposium on Fractures and Other Traumas, Ballroom
2:00 Surgical Film Exhibition (General), Little Theatre
3:30–5:00 Panel Discussion, Music Hall
7:00 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
7:30 Hospital Conference—Trustees, Ballroom, Hotel Statler
8:00 Symposium, General Surgery, Music Hall
8:00 Symposium, Ophthalmology, South Hall A
8:00 Symposium, Otorhinolaryngology, South Hall B

Wednesday

8:00 Meeting of Cancer Committee, Tavern Room, Hotel Statler
9:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
9:30 Hospital Conference, Ballroom
9:30 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
9:30–12:00 Forum on Fundamental Surgical Problems, Music Hall
10:00 Surgical Film Exhibition (General), Little Theatre
State and Provincial Committees:
9:30 Judiciary Committees
10:00 Executive Committees
10:30 Credentials Committees and Committees on Applicants
11:00 Panel Discussions
Ophthalmology, South Hall A
Otorhinolaryngology, South Hall B
12:00 Meeting of Board of Governors, Lattice Room, Hotel Statler
1:30–3:00 Panel Discussion, Music Hall
2:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
2:00 Symposium on Cancer, Ballroom
2:00 Surgical Film Exhibition (General), Little Theatre
2:30 Hospital Conference, Club Room B
3:30–5:00 Panel Discussion, Music Hall
6:00 Vandyck Reunion Dinner
7:00 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
7:30 Hospital Conference—Administrative Problems, Club Room B
8:00 Symposium, General Surgery, Music Hall
8:00 Symposium, Ophthalmology and Otorhinolaryngology, South Hall A

Thursday

9:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
9:30 Hospital Conference, Ballroom
9:30 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
9:30–12:00 Forum on Fundamental Surgical Problems, Music Hall
10:00 Surgical Film Exhibition (General), Little Theatre
11:00 Panel Discussions
Ophthalmology, South Hall A
Otorhinolaryngology, South Hall B
1:30 Adjourned Meeting, Governors, Music Hall
1:45 Annual Meeting, Fellows, Music Hall
2:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
2:00 Hospital Conference, Ballroom
3:00 Panel Discussion—Graduate Training in Surgery, Club Room B
3:30–5:00 Panel Discussion, Music Hall
3:30 Surgical Film Exhibition (General), Little Theatre
3:30 National and Regional Fracture Committees, Club Room C
4:00 Committee on the Library
7:00 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
8:00 Symposium, General Surgery, Music Hall
8:00 Symposium, Ophthalmology, South Hall A
8:00 Symposium, Otorhinolaryngology, South Hall B

Friday

9:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
9:30 Surgical Film Exhibition (Ophthalmology and Otorhinolaryngology), Little Theatre
9:30–12:00 Forum on Fundamental Surgical Problems, Music Hall
10:00 Surgical Film Exhibition (General), Little Theatre
10:30 Assembly of Initiates, Ballroom
1:30–3:00 Panel Discussion, Surgery of the Stomach, Music Hall
2:00 Clinics, Demonstrations and Clinical Group Conferences, Selected local hospitals
2:00–4:00 Panel Discussions
Obstetrics, South Hall A
Plastic Surgery, Club Room C
Neurological Surgery, Club Room A
Thoracic Surgery, South Hall B
Urology, South Hall C
Orthopedic Surgery, Club Room B
2:00 Surgical Film Exhibition (General), Little Theatre
3:30–5:00 Panel Discussion, Surgery of the Vascular System, Music Hall
8:00 Convocation, Music Hall

EVENING SYMPOSIA

GENERAL SURGERY

Tuesday, 8:00 p.m.

Care of the Patient before and after Operation
Fluid and Electrolyte Balance. CARL MOYER, Eloise, Michigan.
Nutritional Preparation of the Substandard Risk Patient. RICHARD L. VARCO, Minneapolis.
Use of Blood and Blood Substitutes. JOHN D. STEWART, Buffalo.
Blood Transfusion Problems, with Special Reference to the Rh Factor. ALEXANDER S. WIENER, Brooklyn.
Safe Conduct of the Patient Through Operation. OWEN H. WANGENSTEEN, Minneapolis.

Wednesday, 8:00 p.m.

Venous Thrombosis and Prevention of Pulmonary Embolism
Interruption of Deep Veins. ARTHUR W. ALLEN, Boston.
Sympathetic Nerve Block. ALTON OCHSNER, New Orleans.
Anticoagulants. D. W. GORDON MURRAY, Toronto.
Fracture Oration
Modern Methods in the Treatment of Fractures. EDWIN W. RYERSON, Chicago.

Thursday, 8:00 p.m.

Antibiotic and Chemotherapeutic Agents in Surgery
Pathologic Physiology of Surgical Infections. JOHN S. LOCKWOOD, New Haven.
Penicillin—Its Use in Surgery and Influence on Earlier Types of Chemotherapy. WILLIAM A. ALTEMEIER, Cincinnati.
Streptomycin. HORTON C. HINSHAW, Rochester.
Correlation of the Use of Antibiotic and Chemotherapeutic Agents with General Principles of Surgery. CHAMP LYONS, New Orleans.

OPHTHALMOLOGY

Tuesday, 8:00 p.m.

Orbital Reconstruction Including Prosthesis
Acrylic Prosthesis. A. D. RUEDEMANN, Cleveland.
Basket Implant. NORMAN L. CUTLER, Wilmington.
Reconstruction of Orbital Floor Defects. Major ARTHUR E. SHERMAN, Springfield, Missouri.

Thursday, 8:00 p.m.

Recent Advances in Ophthalmology
Surgical Applied Anatomy in Eye Surgery. MEYER WIENER, Coronado.
Visual Field Defects Associated with Head Injuries. JOHN S. MCGAVIC, Fort Madison
The Management of Non-Magnetic Intraocular Foreign Bodies. HARVEY E. THORPE, Pittsburgh.
The Treatment of Strabismus in Children. MAYNARD C. WHEELER, New York.

OTORHINOLARYNGOLOGY

Tuesday, 8:00 p.m.

Treatment of Deafness
The Management of the Chronic Suppurating Ear. JAMES H. MAXWELL, Ann Arbor.
The Fenestration Operation. GEORGE E. SHAMBAUGH, JR., Chicago.
Use of Radium for Conductive Deafness. JOHN E. BORDLEY, Baltimore.

Thursday, 8:00 p.m.

Surgery of the Nasal Accessory Sinuses
Indications for Surgery in the Light of the Use of Antibiotics. HARRY P. SCHENCK, Philadelphia.
Intranasal Surgery. JOHN J. SHEA, Memphis.
External Operations.

PLASTIC SURGERY OF THE HEAD AND NECK

Wednesday 8 p.m.

Cancellous Bone Grafts to the Jaw. TRUMAN G. BLOCKER, Galveston.
Repair of Nasal Defects with Free Composite Grafts of Skin and Cartilage from the Ear. JAMES B. BROWN, St. Louis.
Studies in the Anatomy and the Repair of Cleft Palate.
Preservation of Function Following Resections of Jaw Tumors. LOUIS T. BYARS, St. Louis.

PANEL DISCUSSIONS

GENERAL SURGERY

Monday, 1:30–3:00 p.m.

Rehabilitation of the Surgical Patient and Early Ambulation. Leader, HOWARD RUSK, New York.

Monday, 3:30–5:00 p.m.

The Treatment of Cancer of the Large Bowel. Leader, FREDERICK A. COLLER, Ann Arbor.

Tuesday, 1:30–3:00 p.m.

Thiouracil in Thyroid Disease. Leader, FRANK LAHEY, Boston.

Tuesday, 3:30–5:00 p.m.

Recent Trends in the Management of Carcinoma of the Cervix. Leader, JOE VINCENT MEIGS, Boston.

Wednesday, 1:30–3:00 p.m.

Anesthesia. Leader, HENRY K. BEECHER, Boston.

Wednesday, 3:30–5:00 p.m.

Protein Metabolism in the Surgical Patient. Leader, ROBERT ELMAN, St. Louis.

Thursday, 3:30–5:00 p.m.

Spinal Cord Injuries. Leader, HOWARD C. NAFFZIGER, San Francisco.

Friday, 1:30–3:00 p.m.

Surgery of the Stomach. Leader, ROSCOE R. GRAHAM, Toronto.

Friday, 3:30–5:00 p.m.

Surgery of the Vascular System. Leader, DANIEL C. ELKIN, Atlanta, Georgia.

SURGICAL SPECIALTIES

Friday, 2:00–5:00 p.m.

Orthopedic Surgery Panel. (Subject to be announced.) Leader, CARL E. BADGLEY, Ann Arbor.
Urology Panel. (Subject to be announced.) Leader, HERMAN L. KRETSCHMER, Chicago.
Plastic Surgery Panel. (Subject to be announced.) Leader, ROBERT H. IVY, Philadelphia.
Neurological Surgery Panel. (Subject to be announced.) Leader, FRANCIS C. GRANT, Philadelphia.
Obstetrics Panel. (Subject to be announced.)
Thoracic Surgery Panel. (Subject to be announced.) Leader, RICHARD H. SWEET, Boston.

OPHTHALMOLOGY

Panel discussions in the field of Ophthalmology are planned for Tuesday, Wednesday, and Thursday mornings at 11:00 o'clock, on the following subjects: Retinal Detachment; Glaucoma; Keratoplasty.

OTORHINOLARYNGOLOGY

Panel discussions on subjects in the field of Otorhinolaryngology are planned for Tuesday, Wednesday and Thursday mornings at 11:00 o'clock on the following subjects, respectively: The Treatment of Ménière's Disease; Osteomyelitis of the Skull; Rehabilitation of the War Deafened.

SYMPOSIUM ON FRACTURES AND OTHER TRAUMAS

AT 2:00 o'clock on Tuesday afternoon there will be held a symposium on Fractures and Other Traumas under the direction of Robert H. Kennedy of New York. This symposium will be devoted to a number of brief presentations by specialists in various fields concerning new or improved methods adopted during the war which are applicable to injury in civilian surgery. The aim is to give a rapid survey of worthwhile gains made during the war which may prove of lasting value in the field of trauma.

Among the fifteen or twenty short papers which are planned are the following:

Bone Grafts. GEORGE K. CARPENTER, Nashville.
Spinal Cord Injuries. DAVID H. POER, Atlanta.
Injuries to the Rectum. EDMUND J. CROCE, Worcester.
Transportation of Fractures. WILLIAM J. STEWART, Columbia.
Replacement of Skin Defects. JAMES B. BROWN, St. Louis.
Fractures of the Carpal Scaphoid. MATHER CLEVELAND, New York.
Amputations. RUFUS H. ALDREDGE, New Orleans.
Training of Amputees. HENRY H. KESSLER, Newark.
Rehabilitation. Col. A. WILLIAM REGGIO, Washington.
Compound Fractures Treated with Penicillin and Delayed Primary Closure. OSCAR P. HAMPTON, Jr., St. Louis.

SYMPOSIUM ON CANCER

A symposium on cancer is planned for Wednesday afternoon. The Cancer Committee of the College has done outstanding work in furthering the development of cancer clinics in hospitals and providing for the registration of cured cases of malignant disease in the cancer archives. The chairman of this committee will give a brief review of these activities of the College in opening the symposium.

Other subjects of practical interest are under consideration for inclusion in the program, which is being planned to interest surgeons, pathologists, and radiologists.